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Feasibility of a Traffic Operations Center for South Dakota

Study SD2022-08
Final Report

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16. Abstract

The South Dakota Department of Transportation (SDDOT) is pursuing a statewide Traffic Operations Center (TOC) to improve transportation on its roadways. The effort required to establish a TOC is significant; thus, the SDDOT commissioned a feasibility study and report. The project gathered stakeholder input, performed research on nationwide practices, and interviewed several nearby state DOTs on TOC functions, best practices, and lessons learned. Common TOC practices were described and categorized. Existing, planned, and future technologies used by SDDOT were documented in operational concepts, where examples were written to demonstrate what traffic operations would look like with a TOC compared to current practice. An alternatives analysis evaluated five models of a TOC ranging in complexity against a no-build option. The findings of the report recommend continuing efforts toward a TOC by starting with a simple TOC deployment and building toward a more complex 24/7/365 facility. Recommended next steps include conducting a facility assessment of the Sioux Falls Public Safety Campus, following the systems engineering processes to develop more planning documents, and pursuing grants to reduce the financial burden on the SDDOT.

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Acronym	Definition
AI	Artificial Intelligence
ATMS	Advanced Traffic Management System
ATTAIN	Advanced Transportation Technologies and Innovation
AVL	Automatic Vehicle Location
BIT	Bureau of Information and Telecommunications
CAD	Computer-Aided Dispatch
CCTV	Closed Circuit Television
CEJST	Climate and Economic Justice Screening Tool
CMAQ	Congestion Mitigation and Air Quality
DMS	Dynamic Message Sign
DOT	Department of Transportation
EMS	Emergency Medical Services
ESS	Environmental Sensor Station
FHWA	Federal Highway Administration
FIRST	Freeway Incident Response Safety Teams
HSIP	Highway Safety Improvement Program
INFRA	Infrastructure for Rebuilding American
Iowa DOT	Iowa Department of Transportation
IRIS	Intelligent Roadway Information System
ITS	Intelligent Transportation Systems
MDC	Mobile Data Collector
MDSS	Maintenance Decision Support System
MDT	Montana Department of Transportation
MnDOT	Minnesota Department of Transportation
MPO	Metropolitan Planning Agency
NDDOT	North Dakota Department of Transportation
NDOT	Nebraska Department of Transportation
NHS	National Highway System
NWS	National Weather Service
POE	Port of Entry
PROTECT	Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation
PSAP	Public Safety Access Point
PSC	Public Safety Campus
RAISE	Rebuilding American Infrastructure with Sustainability and Equity
RTMC	Regional Transportation Management Center
RWIS	Road Weather Information System
SDDOT	South Dakota Department of Transportation

Acronym	Definition
SDHP	South Dakota Highway Patrol
SDSU	South Dakota State University
SHRP 2	Strategic Highway Research Program
SMART	Strengthening Mobility and Revolutionizing Transportation
SOP	Standard Operating Procedure
SS4A	Safe Streets for All
TMC	Transportation Management Center
TOC	Traffic Operations Center
USD	University of South Dakota
VSL	Variable Speed Limit
WYDOT	Wyoming Department of Transportation

1.0 EXECUTIVE SUMMARY

1.1 Introduction

South Dakota is a primarily rural area with major urban centers along the eastern and western borders. Like all states, the South Dakota Department of Transportation (SDDOT) faces typical traffic and transportation concerns such as congestion, work zones, and crashes. At the same time, South Dakota faces challenges not seen everywhere in the country – such as severe winter weather and the Sturgis Motorcycle Rally, which draws between 400,000 to 700,000 attendees annually. In fact, the rural makeup of the state poses its own challenges for SDDOT. The state's low population density poses a challenge when determining where to make improvements or deploy solutions. Responding to crashes, performing winter weather operations, or providing routine maintenance to roadways may require more resources and take longer than similar actions in denser areas.

To combat these challenges, SDDOT has implemented several solutions. One of these solutions is the use of Intelligent Transportation Systems (ITS), such as Dynamic Message Signs (DMS), Closed-Circuit Television (CCTV) cameras, environmental sensors, and mobile data collectors on snowplows. SDDOT also works to communicate with the public through means such as its SD511 traveler information system.

These approaches have helped address issues, but the systems controlling ITS devices are typically not integrated with each other. Controlling, updating, or using these tools is often manual and time-consuming. SDDOT staff may not have time to manage the equipment or software on top of their normal responsibilities.

At the same time, traffic within the state is increasing. SDDOT is seeking to expand its ITS network and make use of newer technologies, such as Variable Speed Limits (VSL). Expectations of the public regarding the level of information provided have risen. To better serve the needs of South Dakota's transportation systems now and in the future, a dedicated Traffic Operations Center (TOC) seems needed.

A TOC would provide a hub for transportation efforts throughout the state. Integrating systems, coordinating with partner agencies, and responding to incidents will improve the safety and efficiency of South Dakota roads. Though the benefits are promising, challenges such as funding, securing a workforce, and meeting the needs of a rural population pose risks and require a meticulous approach.

Thus, SDDOT commissioned a feasibility study for a state-wide Traffic Operations Center (TOC). The study evaluated the conditions, benefits, and concerns surrounding a TOC to develop several approaches and to recommend an appropriate approach for the state. Bolton & Menk and WSP partnered to create this report, which is broken into four phases: the literature review, operational concepts, alternatives analysis, and recommendations.

1.2 Literature Review

The project team began by reviewing national literature related to designing, deploying, and operating TOCs. Next, the project team conducted a peer exchange with surrounding states to understand their respective TOCs and how approaches taken by these agencies could be applied to a South Dakota TOC concept. Lastly, the project team conducted an in-person and virtual workshop with stakeholders in Rapid City, Pierre, and Sioux Falls to educate stakeholders and identify the needs and opportunities for a TOC in South Dakota.

The national literature review found TOC functions across the country, categorizing them into traffic management, traveler information, road weather management, maintenance and construction information management, special event management, public safety and incident management, commercial vehicle operations, and data management. The functions were intended to be a list of potential TOC applications rather than operations the SDDOT TOC must perform. The literature review also found common approaches for dividing responsibility between different agencies, including: DOT Only, where the TOC was run solely by the DOT or a similar agency; DOT with Some Oversight, where the TOC was led by a DOT who may share some responsibilities with other agencies; Single Discipline/Multi-Agency TOC, where multiple agencies shared resources but focused solely on transportation; and Multi-Discipline/Multi-Agency TOC, where the agencies involved included non-transportation disciplines, such as emergency services.

The project team met with representatives from TOCs or Transportation Management Centers (TMCs) in North Dakota, Minnesota, Iowa, Nebraska, Wyoming, and Montana. Members of these agencies provided details about their TOC/TMC model, best practices, and lessons learned. Many of the agencies began as smaller facilities with limited functionality or hours and have grown over time. Representatives also described challenges like those expected in South Dakota, such as obtaining funding and staff. Attendees also offered ways they have combatted these challenges, such as sharing existing DOT facilities, allowing remote work, and offering seasonal bonuses.

The project team also solicited input from SDDOT staff, who were supportive of the effort to develop and centralize traffic operations into a formal TOC. Staff recounted current successes of traffic operations, as well as challenges they face, such as a lack of clarity on existing technologies and difficulty making updates in a timely manner. Many staff cited the temporary TOC run by the South Dakota Highway Patrol (SDHP) and SDDOT each year during the Sturgis Motorcycle Rally as a successful example of a TOC. SDDOT staff desired a quick rollout of a TOC but expressed concerns over cost and staffing.

1.3 Operational Concepts

The SDDOT currently operates and maintains ITS devices to support traffic management and operations across the state. While SDDOT is currently planning for the deployment of a variable speed limit system, ITS devices such as DMS, CCTV cameras, environmental sensor stations (ESS), and mobile maintenance vehicle data collectors are typically managed individually with non-integrated software tools provided by equipment vendors. This section summarizes the operational concept for a statewide TOC. The primary purpose of the operational concept is to describe how a statewide TOC can unify control and enhance monitoring, management, maintenance, and operation of existing transportation management systems.

Functions of the TOC were divided into eight categories: traffic management, traveler information, road weather management, maintenance and construction information management, special event management, public safety and incident management, commercial vehicle operations, and data management. For each of these categories, the team documented current SDDOT practices and systems, planned work, and future opportunities.

For each of the eight TOC categories, five examples based on real-world situations were used to compare current practices with potential responses under a Traffic Operations Center. These examples were categorized as normal operations, severe weather, traffic incidents, special events, and equipment failures. The SDDOT ITS Program, SDDOT Division of Operations, and SDHP are the stakeholders most involved in daily traffic and transportation operations; thus, the current practices for

each example were broken down by those agencies. Finally, a description of a likely response was included to showcase how responses could change.

This portion of the report is intended as examples rather than comprehensive lists of traffic operations. Additionally, how an SDDOT TOC would respond is a hypothesized reaction dependent on the future, final design of the TOC. However, these schemas demonstrated the expectations of a TOC, which provides more tools to monitor and control traffic and facilitate communication between stakeholders. A staffed TOC with clearly defined roles is aware of more incidents as they occur and can take more action with both existing and planned technology.

1.4 Alternatives Analysis

An alternatives analysis was performed by developing five models for a TOC and comparing them to a no-build alternative. The models were evaluated on functionality, facility, workforce, coverage, and costs. The simpler models were designed to perform fewer functions, make use of remote or existing DOT facilities, and limit hours to primarily business hours with some additional coverage for special circumstances, such as severe weather. These models had smaller staffing needs and lower costs. More complex models would be able to perform more traffic operations, utilize a central, physical facility, and operate 24/7/365. However, these deployments required more employees and were costly in comparison.

The simplest model was the Remote and Focused model, which would require no physical location. All workers would conduct operations from virtual workstations. It would also require the fewest staff of all models. Operations would primarily take place around typical business hours with the ability to extend hours during circumstances such as large events or inclement weather. The remote and focused model would not provide all functionalities. Commercial vehicle operations, maintenance and construction information management, and data management would not be included. As a result, this model had the lowest cost of all proposed TOCs.

The next model is the Distributed and Focused model. Like the Remote and Focused model, the facility would operate around business hours and during special circumstances. However, this model would include some physical workstations in existing key SDDOT locations along with virtual ones. Additionally, the facility would include all eight TOC functions and would require more staff. The addition of more functionality, staff, and physical locations does result in a higher overall cost.

The Hybrid 24/7 model is identical to the Distribute and Focused model except that hours would be expanded to 24/7/365 functionality. As a result, several more staff are needed to support this model. There would be a relatively small increase in cost to accommodate the salary and equipment needs of the additional staff.

The two final models, Centralized 24/7 and Co-Located 24/7, are very similar. Both models would have a single central facility designed specifically to be a TOC. Like the previous two models, they would conduct all eight TOC functions and would need more staff than previous models. The key difference is that the Centralized 24/7 model would be a standalone facility just for TOC use, while the Co-Located option would share space with partner agencies, likely the SDHP or other emergency services. The Co-Located space would grant more options for collaboration and potential staff sharing. Due to the cost of a large physical space, more TOC technologies, and higher numbers of staff, these two models are the most expensive.

While the impacts on transportation will depend on the model chosen, each option will yield many benefits. For example, most delays within the state come from non-recurring, unpredictable events.

TOC staff will be notified of these events sooner and can choose from a wider array of solutions to help combat these delays. Where technology is available, TOC staff can monitor CCTVs and sensor data for crashes or delays, potentially before they are reported by other means. If intervention is necessary, TOC staff can quickly reach resources such as SDHP or field staff who can help clear roadways. The faster detection and response times have an important impact on safety, where the risk of secondary accidents increases quickly, and a few minutes can mean life or death in a serious accident.

A TOC is a helpful tool for many transportation solutions such as variable speed limits or truck parking availability information systems. Even technology that requires limited staff time can be difficult to deploy if there are no workers on call to use it. A TOC provides the personnel and resources for this kind of work and offers a template for future expansion when the need arises.

1.5 Recommendations

After reviewing the previous stages of the project, the team proposed four recommendations for the next stages of the SDDOT TOC initiative.

1.5.1 Advanced Deployment through Phased Implementation

Based on the benefits found during the literature review and alternatives analysis, the team recommends the SDDOT continue to move forward toward the creation of a TOC. Regardless of the scale of the model chosen, implementing a new TOC will require significant time and effort. Given the significant challenges involved, the team recommends beginning with a simpler TOC model such as alternative B or C and progressing toward a more advanced, 24/7 facility located in Sioux Falls. This will allow for faster deployment, requiring fewer resources at the onset but adding desired functionality over time.

1.5.2 Conduct Facility Assessment

The Sioux Falls Public Safety Campus has been identified as a promising space for the permanent TOC. The building has features such as redundant power, a robust communications network, proximity to emergency responders, and room to house the TOC. It also is housed in Sioux Falls, which has amenities that may draw candidates to positions. To ensure this facility would be the best fit, stakeholders for the TOC and Public Safety should work together to assess all needs and requirements.

1.5.3 Continue Advancing Key Systems Engineering and Planning Deliverables to Ensure Successful Deployment

The next phases of the project continue key systems engineering and planning processes and develop related deliverables, including creation of documents such as a Concept of Operations, Requirements, a Business Plan, and an Operations Plan. This work will continue to prepare the project for design and implementation. It will also prepare the project to apply for grants, as all ITS projects that receive federal funding are required to undergo the systems engineering process.

1.5.4 Pursue Competitive Grant Funding to Expedite Delivery and Reduce Financial Burden of Plan

Establishing an SDDOT TOC will require a large amount of capital. However, numerous federal grant programs designed to help fund such programs can reduce the financial burden to the SDDOT and expedite project delivery. Several grant programs are identified as opportunities for funding. When applying for grants, it is important to focus on benefits that align with the grant goals. These goals differ between programs but commonly align with safety, equity, environmental, and rural improvements.

2.0 INTRODUCTION

2.1 Project Scope

South Dakota's ITS network is expanding, adding new devices and new systems to improve transportation within the state. Traffic is also increasing, increasing public demand for real-time and reliable traveler information and incident response. These changes have created a demand for a unified and dedicated 24/7/365 TOC to integrate South Dakota's ITS devices, improve roadway operations and maintenance, and provide enhanced agency coordination.

The Feasibility of a Traffic Operations Center for South Dakota project included research and analysis of common TOC practices and SDDOT resources to identify options for an SDDOT TOC and recommend next steps. Included within this report are a literature review, operational concepts, alternatives analysis, and recommendations.

2.2 Project Purpose

A TOC will serve as a hub for traffic management and operations. The purpose of the project is to integrate TOC functions currently performed by separate SDDOT offices and systems to better manage the state's ITS network, expand monitoring and condition reporting, and effectively manage and operate new, advanced transportation technologies.

The TOC concept envisioned would operate 24/7/365 to monitor the transportation network, dispatch maintenance resources, and provide travel information. The TOC concept will allow SDDOT to unify resources, formalize staffing responsibilities and operational procedures, and potentially pursue and incorporate new, more sophisticated transportation systems such as connected vehicle technologies and big data applications. Furthermore, establishing a statewide TOC will enhance coordination and cooperation between SDDOT and partner agencies such as public safety answering points (PSAP), law enforcement, and local entities.

2.3 Geographic Limits

Regardless of the physical location of the TOC, its geographical scope will be the entire state of South Dakota with focus on the state transportation network (Interstate and state highways).

2.4 Intended Audience

The SDDOT will be responsible for a TOC. Therefore, this document is written primarily for the SDDOT's perspective (e.g., SDDOT staff) but considers coordination with operational partners and stakeholders statewide. Input from external operational partners will be essential to help plan for the TOC's eventual evolution. Vendors, contractors, and other partners that have a role or interest in the operation of the TOC and new TOC functionality will also benefit through improved understanding.

2.5 Operational Partners and Stakeholders

Several agencies collaborate daily to perform transportation functions and services. The agencies identified and described in this section currently have roles or responsibilities in SDDOT transportation activities and will have a stake in the statewide TOC concept.

2.5.1 Internal Operational Partners

2.5.1.1 SDDOT Division of Operations

South Dakota's transportation system and its oversight are divided into four regions with three areas in each region. Staff within the region and area offices are responsible for day-to-day activities like traffic incident response, weather event response, winter maintenance, special event management, and work zone management. Region and area staff are responsible for activities that may be shared with a future TOC, including monitoring traffic cameras and ESS data for situational awareness.

The SDDOT Division of Operations also includes Operations Support staff. These staff provide support and assistance to SDDOT field construction and maintenance staff with updating the state's SD511 traveler information system. During major weather events, Operations Support staff collaborate with region and area engineers to report road closures and travel advisories, coordinate with SDHP, and communicate with neighboring states.

2.5.1.2 SDDOT ITS Staff

SDDOT ITS staff are responsible for ITS project planning, design, delivery, operation, and maintenance. The SDDOT ITS staff monitor the performance of ITS devices and can control ITS devices (view cameras, post messages to DMS, etc.) when needed.

2.5.2 External Operational Partners

In addition to internal operational partners, SDDOT frequently coordinates with the following external operational partners.

2.5.2.1 South Dakota Office of Emergency Management

The South Dakota Office of Emergency Management strives to create a rapid, effective, and compassionate emergency management system that prepares citizens, communities, and the state to be self-reliant when facing emergencies and disasters. This office focuses on four key pillars to plan for emergencies, coordinate response, aid in disaster recovery and reduce or eliminate loss if the same event should happen again.

2.5.2.2 South Dakota Bureau of Information & Telecommunications

The South Dakota Bureau of Information and Telecommunications (BIT) is responsible for supporting the technological needs of other State agencies. BIT's responsibilities may overlap with SDDOT's for ITS and other technology-related systems. Often, these systems require software, databases, and networks that require the skills and support of BIT. It is crucial that additional technology and its requirements are discussed with BIT prior to implementation.

2.5.2.3 South Dakota Highway Patrol

In addition to enforcing the law, the SDHP assists motorists, supports emergency officials, aids in emergency situations, and works to reduce roadway crashes. SDHP works with law enforcement agencies across the state to serve residents and travelers. SDHP is usually involved in response to traffic incidents on state and local highways. SDHP also works with SDDOT staff to establish and communicate road closures and re-openings.

2.5.3 Other Stakeholders

This initiative may involve other stakeholders that would have no direct role in TOC operations. However, these stakeholders may have feedback that impacts design, planning, or implementation. Involving these stakeholders early in the process will allow the project to benefit from their experience and needs and prevent difficult changes later.

2.5.3.1 University Transportation Research Centers

The SDDOT often partners with universities, including South Dakota State University, the South Dakota School of Mines and Technology, and the University of South Dakota, to conduct transportation related research within the state. The SDDOT may share data with these institutions for their research. Research conducted by the universities often provides direction for SDDOT efforts and often provides metrics and analysis of SDDOT systems.

2.5.3.2 Local Agencies (Cities and Counties)

SDDOT coordinates with many local agencies to provide better service to the community. Information sharing between agencies is essential to maintaining the larger transportation network. Traffic impacts are rarely limited to one jurisdiction. Thus, communication and active collaboration are essential for inter-agency communications.

2.5.3.3 Metropolitan Planning Organizations

Metropolitan planning organizations (MPOs) control transportation planning for urban areas larger than 50,000 people. In South Dakota, they include Sioux Falls, Rapid City, and Sioux City. MPOs may provide insight into their regions that would not necessarily be captured by local agencies alone. They may also play a role in championing inter-agency coordination. For example, Tri-State and Sioux Falls traffic incident management groups facilitate relationship building and detour route planning.

2.5.3.4 Federal Highway Administration

FHWA provides important guidance such as the system engineering framework and documentation of similar initiatives across the country. In addition to the knowledge resources, the FHWA also provides funding for DOTs.

3.0 PHASE I – LITERATURE REVIEW

3.1 National Literature Review

The project team conducted a brief literature review to understand national best practices and approaches undertaken to design, deploy and operate TOCs. The review included potential TOC functions, configurations, staffing and future-proofing considerations. The primary goals of the literature search were to 1) better understand the range of functions and related activities that a TOC could support, and 2) present pertinent information for stakeholders to consider when developing a South Dakota TOC concept. Information related to TOC configurations, staffing, and other best practices are presented in later sections of this document.

3.1.1 Overview of Potential TOC Functions for South Dakota

A TOC can engage in several functions to improve safety and mobility and operate transportation networks more effectively. A brief overview of functions that may be applicable to South Dakota's situation and environment is provided in the following sections. The information is not intended to be exhaustive but rather to provide a broad view of the functions that may be integrated into a South Dakota TOC concept. Potential TOC functions include:

- traffic management
- traveler information
- road weather management
- maintenance and construction information management
- public safety and traffic incident management
- special event management
- commercial vehicle operations
- data management

3.1.1.1 Traffic Management

Traffic management is the most fundamental function that a TOC can support. A TOC uses advanced technologies that may include cameras, dynamic message signs, vehicle detection, traffic signals, ramp meters, and freeway gates to monitor, control, and optimize traffic flow on transportation networks. A TOC may engage in many types of activities, depending on agency capabilities and needs. Some potential activities that may be applicable to the South Dakota environment are listed below. Traffic monitoring, queue warning, road closure management, and variable speed limits (Figure 1) may be particularly applicable to South Dakota.

Figure 1: Variable Speed Limit Sign

- traffic monitoring
- traffic signal control
- queue warning
- dynamic lane management
- ramp metering
- variable speed limits
- road closure management
- wrong way vehicle detection

3.1.1.2 Traveler Information

Real-time information collected by a TOC can be used to support pre-trip and enroute travel information. Information related to traffic conditions, road closures, weather information, incidents and other advisories can be disseminated to drivers enroute using dynamic message signs, highway advisory radio, and 511 systems. TOCs can also share information with operational partners including the media, transit management agencies, and emergency response and management agencies. TOC responsibilities include monitoring the status of travel information technologies and reporting system malfunctions and failures to maintenance or other appropriate individuals. Traveler information activities typically fall into the following categories:

- pre-trip travel information
- enroute travel information

3.1.1.3 Road Weather Management

TOCs can support road weather management functions by monitoring, assessing, and responding to predicted and real-time weather conditions. First, TOCs can collect data from environmental sensors installed along roadways or on vehicles to monitor pavement and air temperatures, ice presence, precipitation, and snow accumulation. This information can be shared with drivers and operational partners or integrated into maintenance decision support systems to optimize maintenance and construction activities. This includes making effective decisions on when and where to treat roadways and the amount of material to allocate toward these activities. Information and data can also be used to provide drivers with alerts and warnings at specific locations where weather concerns frequently occur such as low-lying areas and elevated structures. Typical activities that occur within the road weather management functional area are:

- weather data collection
- weather information processing and distribution
- roadway treatment recommendations
- spot weather warnings

3.1.1.4 Maintenance and Construction Information Management

TOCs can support maintenance and construction management by monitoring and managing activities within and immediately upstream of work zones. Responsibilities may include using various tools and processes to advise drivers of these activities and coordinating with maintenance and construction staff on the timing and status of maintenance and construction activities. Typical activities that occur in the maintenance and construction management functional area are:

- seasonal maintenance operations
- roadway maintenance and construction
- maintenance and construction vehicle tracking
- work zone safety monitoring and management

3.1.1.5 Public Safety and Traffic Incident Management

TOCs can support public safety and traffic incident management functions by responding to emergency response and management agency requests for road network condition status. They can also support requests for assistance in preempting traffic signals for emergency response vehicles, closing lanes to traffic, and establishing road and ramp closures to enhance response and safety. During traffic incidents and emergencies, a TOC can monitor incidents, collect incident details, and convey pertinent details to emergency response and management agencies to initiate an effective response. Where available, a TOC can coordinate and dispatch roadway service patrols to assist in protecting the incident scene until emergency responders arrive and to clear the incident. A TOC can also disseminate traffic incident and disaster information—including incident alerts and warnings, alternate routes, and anticipated delays—to enroute and pre-trip travelers and to partner agencies. Typical activities that occur in the public safety and traffic incident management functional area include:

- traffic incident management
- emergency call-taking and dispatch
- management and coordination with roadway service patrols
- disaster response and recovery
- evacuation and reentry management
- disaster traveler information

3.1.1.6 Special Event Management

TOCs can support special event management through advance planning and coordination with operational partners to develop and deploy operational strategies and traffic control plans (Figure 2). During the event, the TOC can monitor operations near the special event and disseminate travel information. It can also serve as a central meeting place where all impacted agencies can plan for the event. Activities associated with special event management include:

- special event coordination and planning
- special event traffic management

Figure 2: Motorcyclists Traveling to the Annual Sturgis Motorcycle Rally

3.1.1.7 Commercial Vehicle Operations

A TOC can support commercial vehicle operations by providing real-time truck parking availability information (Figure 3). It can also provide commercial vehicle-specific information that vehicle operators can use to plan trips, identify viable routes, and find available parking. A TOC can also provide or facilitate the exchange of restricted vehicle information, permitting information, inspection station locations and procedures, and weather advisories. In some cases, TOCs also provide or facilitate exchange of oversize/overweight vehicle permit information. Activities that a TOC may engage in for this functional area include:

- real-time analysis of truck parking use and dissemination of parking availability information
- truck oversize/overweight travel planning
- truck weather information

Figure 3: Truck Parking Availability Sign

3.1.1.8 Data Management

A TOC may collect large amounts of data in performing its activities. Data management activities typically include:

- data archiving
- performance management

Data can be collected, archived, and later analyzed for internal use. For example, traffic data can be used for transportation planning purposes and to identify historical trends. It can also be used to assess how well the transportation system is operating in real-time, and based on findings, to identify operational strategies that optimize transportation system performance. Data can also be shared externally with operational partners to supplement data collected by these agencies without incurring additional costs and to demonstrate the benefits of the TOC to the public and decision makers.

3.1.2 Potential TOC Models

Within the United States, TOCs have been designed in many ways specific to agency needs. These designs range from single-agency centers focused on the management and operation of individual transportation facilities to multi-agency centers focused either on a single discipline or multiple disciplines (e.g., traffic management, emergency management, enforcement, etc.). For each model, the geographic coverage may vary as can the location of staff and equipment. For example, TOCs can be centralized, meaning that all systems and staff reside within a single facility, or they can be decentralized, meaning that systems and staff reside in multiple locations with functions distributed or shared between sites. In some instances, TOC functionality may exist in the cloud instead of a physical center. Each of these configurations comes with its respective advantages and disadvantages. This section describes four potential models. The location from which staff perform duties associated with each model can vary from 100% on-site to 100% remote or a blend of both.

3.1.2.1 DOT Only (Individual Agency TOC)

A TOC funded and operated by an individual agency is the simplest configuration. Under this configuration, the DOT (or other traffic management entity) is entirely responsible for the center's operation and maintenance and has the freedom to modify all aspects of the center without having to solicit the input and agreement of other agencies. The DOT is entirely responsible for the planning, design, procurement, installation, operation, and maintenance of all ITS devices, system software, and physical facilities required for the operations of its network. The TOC is also entirely responsible for communicating and collaborating with operational partners. However, this configuration does not facilitate direct (e.g., within the same facility) interaction with other operating agencies. Therefore, during emergencies or major incidents that require coordination with multiple agencies, the TOC may be limited in its effectiveness because it is physically separated from these agencies.

Benefits of this configuration compared to others include:

- straightforward lines of authority
- smaller physical footprint
- greater data security

3.1.2.2 DOT with Some Oversight (Individual Agency TOC, Shared Operations)

A modification to the previous configuration is where an individual agency TOC adds additional oversight functions in coordination with other operational agencies. The TOC primarily operates like an individual agency TOC but assists external agencies with some defined operational responsibilities. These responsibilities typically include monitoring or operating other agencies' transportation systems and technologies (e.g., traffic signal control) in support of cross-jurisdictional coordination. The defined responsibilities can be further governed based on geography (adjacent or overlapping infrastructure), time-of-day (after hours, etc.), or situation (incident, special event).

This configuration can be an effective approach to managing impacts that are temporary in nature, or that may otherwise not justify capital costs associated with changes to a TOC's existing resources. This configuration may result in the need for additional staff or for existing staff to assume additional duties. The costs of these changes may be offset by sharing resources already procured by participating agencies.

This configuration may be helpful for monitoring municipal traffic operations for certain projects where impacts from the freeway may spill onto arterial networks, or for monitoring a partner agency's network during off-hours. Under this configuration, the TOC may assume the additional responsibilities of monitoring municipal transportation networks when municipal staff are unable to or are otherwise unavailable.

Characteristics of this configuration compared to others include:

- maintains benefits of single agency TOC configuration while increasing levels of coordination, collaboration, and performance for regional traffic operations
- shared use of available assets reduces redundant technology costs but increases existing staff workloads and responsibilities
- may be an effective approach for impacts that are temporary in nature

3.1.2.3 Single Discipline/Multi-Agency TOC

A single discipline TOC configuration can integrate any number of traffic management or traffic incident management agencies within a single facility. The single discipline TOC is defined as a multi-agency center focused on either traffic management or traffic incident management only.

In this configuration, agencies must agree on policies and practices, structure, funding, staffing and asset sharing, and delineation of roles. Generally, this configuration is applied to larger metropolitan areas and typically has an operational scope covering a greater number of roadway miles with greater numbers of ITS devices than an individual agency TOC.

Characteristics of this configuration compared to others include:

- higher level of coordination, collaboration, and performance for regional traffic operations or traffic incident management
- greater level of operational complexity and need for multi-agency operational agreements
- lower share of capital and operations costs per agency
- greater monitoring capabilities and assets
- increased direct communication between operational partners
- limited impact to other operational disciplines

3.1.2.4 Multi-Discipline/Multi-Agency TOC

A modification to the single discipline/multi-agency TOC is where additional disciplines are added beyond traffic management or traffic incident management alone. For example, law enforcement or emergency management operations or traffic and incident management could be added. A multi-discipline, multi-agency TOC is the most sophisticated and most complex TOC configuration. Adding additional disciplines can help streamline operations by providing more efficient traffic management, traffic incident management, and emergency management. However, it also adds additional challenges associated with facility space and equipment, information security, lines of authority and leadership, and the need for multi-agency agreements and protocols.

Adding law enforcement or emergency management to a TOC will help develop and enhance inter-agency communication and coordination. Agency integration is expected to ensure that information is shared more routinely, helping to provide a more complete understanding of each discipline's operations.

Characteristics of this configuration compared to others include:

- highest level of coordination, collaboration, and performance for regional traffic operations
- greatest level of operational complexity and need for multi-agency operational agreements
- lowest percentage share of capital and operations costs per agency, although the total cost of the TOC will likely be the highest
- greatest monitoring capabilities and assets
- most direct communication
- improved law enforcement and emergency response operations

3.2 Peer Center Practices

On November 17, 2023, the project team conducted a two-hour virtual peer exchange with representatives of surrounding state traffic management centers (TMCs). The acronyms TOC and TMC are used differently among states, but for all intents and purposes, mean the same thing. The following

sections refer to each center by the name the state uses (i.e., TOC, TMC, and RTMC). The following agencies were invited, with representatives from all but the Iowa DOT participating in the exchange.

- Iowa Department of Transportation (Iowa DOT)
- Minnesota Department of Transportation (MnDOT)
- Montana Department of Transportation (MDT)
- Nebraska Department of Transportation (NDOT)
- North Dakota Department of Transportation (NDDOT)
- South Dakota Department of Transportation (SDDOT)
- Wyoming Department of Transportation (WYDOT)

The goal of the peer exchange was to identify critical issues in planning, operating, and designing a TOC. Peer agency considerations and input were considered important in helping SDDOT continue early planning activities in the pursuit of potentially establishing a statewide TOC. The workshop provided a forum through which SDDOT could ask questions and better understand agency experiences and lessons learned. Topics of interest to SDDOT that were raised during the workshop included, but were not limited to:

- TOC development processes and procurement approaches
- TOC organizational and institutional structures
- TOC location and physical designs
- TOC activities, functions, and technologies
- communication with internal and external stakeholders
- TOC workforce and resource needs
- lessons learned

The information gathered from each agency is summarized in the following sections. In some instances, information collected from the peer exchange is supplemented with information collected through literature review or through project team experience working with the agencies. Key takeaways from agency interviews are:

- The ability to operate remotely is an advantage for unforeseen circumstances such as the COVID-19 pandemic or other events that may impact normal center operations. It may also help attract workers.
- When designing or selecting a facility, make sure the center has extra room to grow over time.
- When designing the interior space, make sure to build in an adequate number of collaboration spaces and conference rooms, as these are used frequently.
- Attracting and retaining operations staff may be difficult. Incentives such as higher salaries or flexible working arrangements may be needed to reduce staff turnover. Non-traditional methods of posting open positions, such as use of social media, may increase the applicant pool.
- Consider having specialized staff on-site to help address issues more quickly when they occur. This may include IT staff or specialized ITS or traffic systems management and operations technicians.
- When considering staffing budgets, be sure to account for staffing that may be needed as the role of the TOC expands. Also consider flexible staffing arrangements that can scale with operational needs. For example, several agencies adjust staffing levels based on season.

Lessons learned specific to individual DOT centers are provided in the following sections.

3.2.1 North Dakota Traffic Management Center

Currently, North Dakota does not have a formal TMC. However, the Department is in the final stages of planning a TMC that will centralize control of the state's transportation management system and enhance delivery of new and existing transportation management functions. The TMC will help NDDOT unify traffic management responsibilities currently performed through separate divisions and districts, expand monitoring and conditions reporting, and effectively manage and operate new and advanced transportation technologies.

NDDOT has made several efforts and investments towards establishing a TMC. They include procuring a new advanced traffic management system (ATMS) software platform and the implementation of technologies to collect real-time data and disseminate actionable information to the public and operational partners. North Dakota will use MnDOT's Intelligent Roadway Information System (IRIS) ATMS software. Additional activities and actions, such as the establishment of a formal TMC, were considered important to help centralize and optimize NDDOT's operations and improve coordination among the Department's internal and external partners.

NDDOT is continually challenged in securing funds and resources needed for a TMC. NDDOT is taking a cost-conscious, phased approach to allow NDDOT to immediately reap the benefits of a TMC while it identifies and acquires the resources needed to implement the Department's long-term TMC vision. In the first phase, NDDOT plans to deploy an interim TMC in Bismarck using existing floor space within its central office. In the second phase, NDDOT may establish a more formal or permanent TMC and may consider a new building, a new facility, or leasing space in another building. NDDOT will also consider co-locating with other agencies, such as the North Dakota Department of Homeland Security and State Radio. Both the near-term and long-term TMC concepts will centralize and expand current traffic and maintenance management functions to a 24/7/365 basis. However, for initial operations, NDDOT is planning to staff the TMC with one or two dedicated staff eight hours a day.

3.2.2 Minnesota Regional Traffic Management Center

MnDOT has a regional transportation management center (RTMC) located in Roseville, MN (Figure 4). The RTMC has been operational for over 20 years (and its predecessor center was operational for about 30 years) and is focused on:

- reducing crashes and congestion
- maximizing use of existing freeway capacity
- increasing freeway speeds during peak periods
- providing accurate, timely traffic information to travelers
- removing stalled vehicles by coordinating with freeway incident response safety teams (FIRST)
- assisting with traffic incident management activities in coordination with State Patrol and FIRST
- enhancing service for transit and carpoolers

MnDOT's Freeway Operations and Maintenance units are co-located with State Patrol in the RTMC facility. The State Patrol shares its computer-aided dispatch (CAD) data with traffic operations staff. Staff can view all information in the CAD system except personal or sensitive information. State Patrol and highway maintenance staff are on duty 24/7, while traffic signal and traffic operations staff are only present in the RTMC from 5am to 10pm. Operations staff work longer hours for significant events such as winter storms. Traffic signal staff can work remotely. Remote work capabilities were added after the COVID-19 pandemic.

The RTMC dispatches the Department's FIRST patrols. It is also responsible for operating Minnesota's E-ZPass express lanes, the state 511 system, and active traffic management strategies. The RTMC uses IRIS software to remotely operate the following technologies within the Twin Cities Metro:

- cameras
- traffic monitoring sensors
- ramp meters
- advisory speed signs
- dynamic message signs
- lane control signs (currently not operational)
- E-ZPass

Figure 4: Exterior and Interior Images of the Minnesota Department of Transportation's Regional Traffic Management Center

MnDOT indicated the number of applicants for open positions has decreased over time, despite dispatch personnel being relatively well paid compared to other DOT positions. Today, MnDOT operates with two dispatchers and two traffic management operators during the peak periods. These staff are in addition to maintenance, traffic signal, IT, and state patrol personnel located in the same facility. In total, the center employs about eighty staff members.

Organizationally, MnDOT's RTMC falls under the Department's Metro District Operations and Maintenance Office.

3.2.3 Iowa Statewide Traffic Management Center

The Iowa DOT Statewide TMC is a statewide center located in Ankeny, Iowa and operates 24/7/365. It serves as the hub of real-time traffic operations for the DOT. Some functions and activities the TMC is responsible for include:

- traffic incident/emergency management
- traffic incident management
- road weather management and emergency transportation operations
- planned special events
- work zones
- special events
- information sharing
- traveler alerts and notifications
- communication with operational partners
- traffic management and monitoring

The TMC has expanded and evolved to meet the continued needs of transportation operations and management and to accommodate the growing need for operations capabilities to be more proactive rather than responsive. The two key aspects of TMC operations are: 1) the staff who provide active

monitoring, coordination, and strategy implementation to respond to traffic and road impacts on Iowa's network, and 2) the systems used to support network monitoring, alerts, communications, and operations strategy implementation.

Iowa DOT contracts with a service provider for operations staff to provide continuous coverage of the TMC and associated systems. The Iowa DOT has used a contracted operations model for the last several years and has been able to effectively adjust that model to provide the optimum staffing levels needed to support TMC operations, even during inclement weather or special events.

Operators at the Iowa DOT TMC communicate with state and local traffic incident responders, Highway Helper responders, Iowa DOT Motor Vehicle Enforcement, Highway Maintenance Supervisors, and Resident Construction Offices to coordinate responses to incidents on the state network. In addition to the TMC's role in providing response coordination and communications during traffic incidents, staff at the TMC participate in pre-planning activities for work zones, forecasted severe weather events, and planned special events.

The TMC plays a critical role in road weather management, particularly during winter months. Events include winter weather, flooding, high winds, and other emergencies that impact safe travel. The TMC actively monitors the National Weather Service, other weather information systems, and corresponding alerts and makes appropriate adjustments to staff schedules to be sure there is adequate coverage for large weather events.

The TMC manages and operates traveler information tools like the 511 phone system, 511 road conditions website, and social media including X and Facebook, and disseminates information to television and radio media outlets.

Each workstation at the TMC has an unobstructed view of the video wall (Figure 5). Images displayed on the video wall can be adjusted and scaled based on the need to monitor specific incidents, work zones, or other locations.

Figure 5: Iowa Department of Transportation Traffic Management Center Workstations and Video Wall

The Iowa DOT uses data collected and generated by TMC systems to support not only real-time operations, but also other key functions, including work zone planning, traffic incident management strategies, Highway Helper operations, and traveler alerts and notifications.

3.2.4 Nebraska Traffic Management Center

Nebraska's statewide TMC was initially created in 2007 as a district operations center for the Omaha metropolitan area. Initially, the center did not operate on a full-time basis, and only would activate for major events or incidents, such as major weather events and traffic incidents. At that time, another center in Lincoln focused on statewide operations. In 2022, NDOT combined its center operations and co-located with State Patrol in a single facility in the Omaha area. However, the State Patrol has since moved its dispatch operations to Lincoln. NDOT does not receive a CAD feed from State Patrol, so this move has made it more difficult for NDOT to exchange information with the State Patrol. NDOT believes that a CAD feed would be valuable to improving their operations.

The State Operations Center's primary goal is to provide accurate and timely information to travelers. The center uses 511 and social media posts to push information to travelers.

The Statewide TMC facility in Omaha is a two-story building. The upper floor has a conference room that is frequently used. NDOT indicated that additional conference rooms should be considered when planning a TMC facility. The lower floor has two rows of four workstations (eight total workstations). The arrangement of workstations is in rows and may not be ideal as talking among operators can be distracting. Each workstation has three or four monitors. In front of the workstations is a large video wall consisting of four larger monitors, and behind them is a situation room used to coordinate with State Patrol and other operational partners. The building was designed to have extra space to accommodate expansion if needed.

When NDOT transitioned to the new operations center, it required additional staff to grow from three employees to ten full-time employees. Part of the need for additional staff was the shift to 24/7 operations. The center also hires seasonal employees during winter.

NDOT requires that new TMC operators complete a minimum 30-day training period. NDOT uses checklists to make sure that operators complete all required training, which includes the second Strategic Highway Research Program (SHRP 2) traffic incident management training. NDOT has found success using social media to recruit for open TMC positions. NDOT emphasized that operators need to be able to write and type efficiently.

NDOT indicated that there could be sensitivities among regional staff when duties are centralized. Some staff may feel that their jobs may be lost or that they would need to relocated if duties were centralized. They also indicated that replacing full-time staff is difficult and that managers should preserve existing staff budgets if workloads should decrease. The number of activities and functions for which a TMC may be responsible is likely to increase over time and having budget for additional staff will be valuable. NDOT added that having a traffic and ITS technician in the same room would be beneficial for resolving related issues more quickly.

3.2.5 Wyoming Traffic Management Center

WYDOT's statewide TMC became operational in the fall of 2008. The TMC is housed in the basement of a leased facility in Cheyenne, approximately one mile north of the WYDOT headquarters complex. Figure 6 shows an image of the TMC floor and workstation configuration. The TMC houses both transportation operations and a dispatch center for the Wyoming Highway Patrol, although they do not share the same operations space. The TMC answers calls from and dispatches maintenance staff and communicates with law enforcement. WYDOT can receive CAD data from the Highway Patrol. The center operates 24/7 and focuses on providing timely and accurate travel information. The center's goal is to change driving behavior to:

Figure 6: Wyoming Department of Transportation Traffic Management Center

- reduce crashes, closure, and fatalities
- increase safety and efficiency

Travel information is disseminated to the public through Wyoming 511, social media feeds, and Wyoming travel information website (www.wyoroad.info). The center provides information such as:

- tire chain requirements
- variable speed limits
- weather advisories
- truck parking locations and number of spaces

The TMC uses a version of IRIS ATMS software originally developed by MnDOT to remotely control the following field devices:

- variable speed limit systems
- environmental sensor stations
- dynamic message signs
- highway advisory radio
- cameras
- automated road closure gates
- travel information map

The TMC has 27 full-time employees plus seasonal employees. In winter, there may be up to 10 additional seasonal employees. WYDOT indicated that hiring seasonal employees is a challenge. It is also a challenge to train them as the process is ongoing and repeats every year. The TMC has offered financial bonuses as an incentive to attract employees. The Legislature also approved higher salaries for TMC staff. WYDOT would prefer to hire and train full-time employees to reduce the effort needed to repeatedly train temporary and seasonal staff. WYDOT indicated that operators must be able to handle stressful situations and adapt to continually changing environments alternating between stressful and quiet periods.

The TMC has developed a VSL policy memorandum to formalize the process of determining speeds to be posted on VSL signs. The process relies heavily on speed sensor data for determining the posted speed, but TMC operators, Highway Patrol, and maintenance personnel can use available weather information to establish appropriate speeds for real-time conditions.

WYDOT indicated that managing and operating a TMC is complex, and that unforeseen circumstances like the COVID-19 pandemic introduced operational challenges that WYDOT had to adjust to quickly. Before 2020, operators were required to work in the center. WYDOT had to quickly adjust to allow operators flexibility to work remotely.

3.2.6 Montana Statewide Transportation Management Center

MDT's Statewide TMC (Figure 7) was established in October 2020. Previously, transportation system management and operations activities were distributed among five districts. Before the TMC was launched, each district had 24/7 coverage only from November through March (Winter season). During other months, districts had only workday hours. A centralized TMC was proposed to provide 24/7/365 support and improve frequency and consistency of public travel information. A TMC was considered to establish infrastructure that would support future ITS deployment. In 2019, MDT approached the Montana Legislature for seven new full-time positions. During winter operations, the TMC adds an additional twenty temporary seasonal employees.

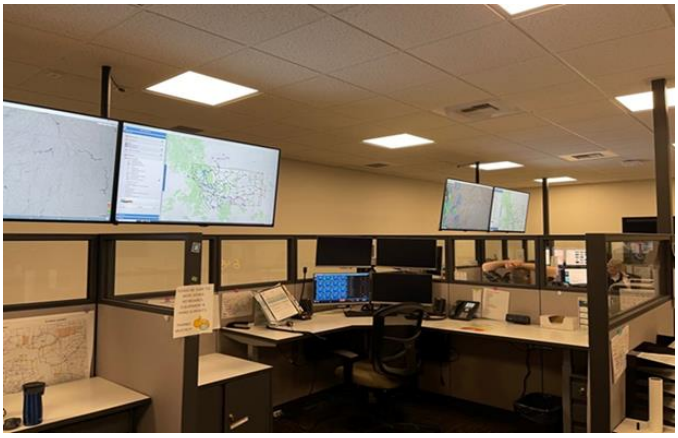


Figure 7: Montana Department of Transportation's Rural Traffic Management Center

To make the transition from district operations to a centralized TMC, MDT had to develop a solution to connect district radios. A solution was developed, but it requires staff to be physically located within the MDT TMC to use the radios, limiting the potential for remote or virtual work arrangements. This has caused some challenges during storms or events that prevent staff from traveling to the TMC.

MDT considered co-locating with Highway Patrol, but the Patrol did not have enough space. Therefore, MDT used existing space within its headquarters building in Helena. The TMC and Highway Patrol have direct lines of communications.

One of the lessons MDT learned was that they mirrored 911 centers staffing arrangements. MDT also stated that the TMC is on its own heating and cooling systems so it can run 24/7. This was a requirement because it uses space within the MDT building, which does not operate 24/7.

Workstations at the TMC are configured in "pods" in a semi-circle, with two computers per workstation. The TMC has IT professionals at headquarters who can help with related issues when needed.

The TMC is part of MDT's Maintenance Division.

3.3 South Dakota TOC Stakeholder Needs

On December 7, 2023, SDDOT hosted an in-person and virtual workshop with stakeholders in Rapid City, Pierre, and Sioux Falls (Figure 8). The purpose of the workshop was to educate stakeholders on a range of TOC functions and concepts and to identify needs and opportunities for a TOC in South Dakota.

Figure 8: Participants at the TOC Stakeholder Needs Workshop in Sioux Falls

Participants indicated that a TOC could support existing activities as well as new functions such as posting variable speed limits and queue warning messages. In general, there was consensus that a TOC could centralize new and existing functions to improve consistency collecting and disseminating information to the public and operational partners.

A TOC was also viewed beneficial in terms of:

- centralizing control of statewide ITS devices
- supporting consistent use of public-facing systems and technologies (e.g., dynamic message signs) and messaging across the state
- supporting efforts to quickly enter and update traveler information and verify that information entered into systems such as SD511 is accurate and valid
- reducing delays in collecting and disseminating information to the public
- supporting and centralizing call-taking functions (particularly during active weather) rather than directing to staff that are off-duty but on-call to support such activities
- supporting additional transportation functions and services that are being considered but have yet to be implemented in the state
- queue warning, particularly on Interstate highways from traffic backing up on exit ramps
- variable speed limits
- commercial vehicle parking availability
- crowdsourcing
- providing 24/7 operations to support regional operations outside normal business hours

Some participants indicated that defining the scope of a TOC is difficult because there is little clarity on how systems and technologies are used and integrated today. Some indicated that for a TOC to be successful, additional equipment and field devices would need to be deployed to detect conditions and events and report them to the public. Some participants indicated that a systems architecture may help to understand the extent that existing technologies are used, how they are used, and how they could potentially be integrated under a TOC concept. Despite this lack of clarity, there was consensus among participants that a TOC would be beneficial and is needed.

There was overall agreement that a TOC can centralize new and existing statewide transportation functions to improve consistency in collecting and disseminating information to the public and operational partners. For example, SDDOT does a good job at reporting road condition information, but information can easily become out of date and must be updated in a timelier fashion. Operators at a TOC can review information posted by staff across the state, use technology to update it with additional

details, and remove it when no longer valid. The TOC can also help request, collect, and review other types of information so it can be quickly passed along to the public. An example would be incident information, which is often reported to SDDOT inconsistently.

Figure 9: South Dakota Temporary TOC Activated for the Annual Sturgis Motorcycle Rally

The TOC was broadly viewed as a good resource to coordinate with operational partners for special events, such as the Sturgis Motorcycle Rally, and during major weather events, such as flooding or winter storms. Some participants indicated that the TOC could serve as the central point of contact and source of transportation related information. It could also be used to enhance coordination for high impact events. For example, public service answering points and 911 centers are often inundated with calls from the public during major events.

Participants indicated that SDDOT has had a long-standing project to integrate CAD data into their SD511 system. The work is scheduled to complete in early 2025. A TOC could potentially serve as a catalyst to move that project forward. It could help support existing 911 center operations by reducing existing staff workloads during peak time so they can dispatch services in a more timely and effective manner. A TOC could also support or absorb a temporary TOC that is activated for several days leading up to and during the Sturgis Motorcycle Rally (Figure 9).

Participants were also interested in how a potential TOC could interface and support other centers. For example, some participants were interested in how a statewide TOC could support other regional TOCs including a planned dispatch center in the Sioux Falls area. Planning for this center has been underway for some time and participants indicated that planning for the Statewide TOC should be closely coordinated with this facility. The new dispatch facility is planned to operate during regular business hours, so a statewide TOC could help support activities outside these hours. It could also support transportation functions such as monitoring network conditions within metro areas outside normal business hours. Several participants indicated co-locating DOT operations with other transportation agencies or disciplines would be beneficial, but others indicated that institutional integration could be complicated and pose a barrier to quick deployment.

Participants indicated that the TOC should reside one of the State's major population centers. Some participants identified a distributed TOC concept with one center in Sioux Falls and another in Rapid City as a potential concept. Participants in Pierre indicated that the local 911 center has had staffing challenges.

4.0 PHASE II – OPERATIONAL CONCEPTS

4.1 Existing Situation

South Dakota is a rural state characterized by long travel distances with significant reliance on highway transportation. General mobility, the economy, and quality of life are all closely tied to reliable travel on the state's roadways. Disruptions from non-recurring sources such as traffic incidents, winter storms, and work zones lead to lost time for travelers and negatively impact system reliability. Delay also contributes to wasted fuel and increased emissions.

While most of South Dakota is rural, its larger communities have unique needs. Timely and accurate roadway conditions are important for both rural and urban areas, but in urban areas such as Sioux Falls and Rapid City, driver expectations and experiences are different. The City of Sioux Falls currently has an operations center and uses ITS technologies such as adaptive signal control. Major events like the Sturgis Motorcycle Rally and South Dakota State University (SDSU) football games primarily occur outside of business hours. These events disproportionately impact travel reliability and introduce challenges to affected communities. Reliability impacts (both non-recurring and recurring) are particularly impactful to freight carriers.

Under the current operational scheme, ITS project development, operations, and maintenance are handled by SDDOT ITS staff. SDDOT Division of Operations staff within region and area offices are responsible for day-to-day items like traffic incident response, weather event response, winter maintenance, special event management, and work zone management. A portion of traffic engineering work (e.g., work zone traffic control) is done at the regional level, while signal design and initial signal setup are typically done by the SDDOT Office of Road Design (except for Sioux Falls). Signal maintenance is done at the municipal level but is supported by Division of Operations staff. For special events such as the Sturgis Motorcycle Rally, a temporary TOC is set up and operated by both the SDDOT and SDHP.

SDDOT is not set up for 24/7/365 response and does not have many formal policies at this time. Staff typically respond from disparate, ad hoc locations, including their own homes. With the growth in the number of ITS devices, the expanding number of functions, and the higher level of expectation for accurate and timely traveler information, a formal, dedicated, and appropriately staffed TOC is considered necessary to successfully manage and operate the state's roadway network.

4.2 Existing Traffic Functions and Services

Currently, SDDOT performs and supports several high-level traffic functions. This section of the document describes the existing functions and services including:

- traffic management
- traveler information
- road weather management
- maintenance and construction information management
- special event management
- public safety and incident management
- commercial vehicle operations
- data management

Appendix A describes how the existing functions and services and future functionality will be integrated into the long-term TOC vision. Appendix B contains the same information, but with decorative elements removed and in a format designed to be more accessible for those using screen readers.

4.2.1 Traffic Management

SDDOT is responsible for managing the statewide transportation network. Activities include collecting, processing, and disseminating a wide range of information and data. Much of this information and data is collected by technologies located along the transportation network that SDDOT is responsible for operating and maintaining. Similarly, SDDOT owns and operates technologies that are used to disseminate information to the traveling public and to operational partners. The ability to quickly detect and verify events impacting the transportation network combined with the ability to inform others helps SDDOT effectively manage operations and take action to reduce impacts. Existing transportation services that fall under the traffic management umbrella are described below.

4.2.1.1 Traffic Monitoring

The SDDOT currently owns and operates cameras throughout the state, mostly connected via cellular modems. Cameras are used to monitor conditions such as weather, congestion, and crashes, or when prompted by other events. SDDOT currently does not have the staff or resources to actively monitor cameras. Images from cameras are made available to the public through 511.

The SDDOT uses vehicle detectors across the state to collect traffic data such as speed, volume, and headway. Detection data is used for real-time monitoring and identifying traffic patterns but is not typically analyzed or stored for more advanced metrics or insights.

Traffic monitoring equipment is often installed with other ITS equipment such as DMS and ESS for monitoring and condition verification as shown in Figure 10.

Figure 10: SDDOT Traffic Monitoring Equipment Installed on an ESS Tower

4.2.1.2 Road Closure Management

SDDOT closes roadways to traffic when driving conditions are unsafe, most frequently during severe winter weather. Road closure decisions are made by executives of SDDOT and SDHP with input from maintenance staff. Once a decision has been made, SDDOT posts closure details to the SD511 Traveler Information System and SDDOT staff manually close the appropriate gates. The SDDOT currently cannot operate these gates electronically or remotely. At some select locations, SDDOT has deployed signs with remotely controlled beacons to show where an Interstate highway is closed, as shown in Figure 11.

Figure 11: SDDOT Road Closed Sign

4.2.2 Traveler Information

SDDOT operates an advanced traveler information system to inform travelers of traffic conditions throughout the state. Traveler information is currently provided via SD511 and DMS.

4.2.2.1 South Dakota 511

SDDOT operates its SD511 traveler information system to inform travelers of traffic conditions throughout the state. The public can access this information through a website (https://www.sd511.org as shown in Figure 12), smart phone app, and by calling the 511 phone number. Users can also sign up for text or email alerts for specific information. Kiosks stationed at Interstate rest areas and ports of entry (POE) also provide SD511 information.

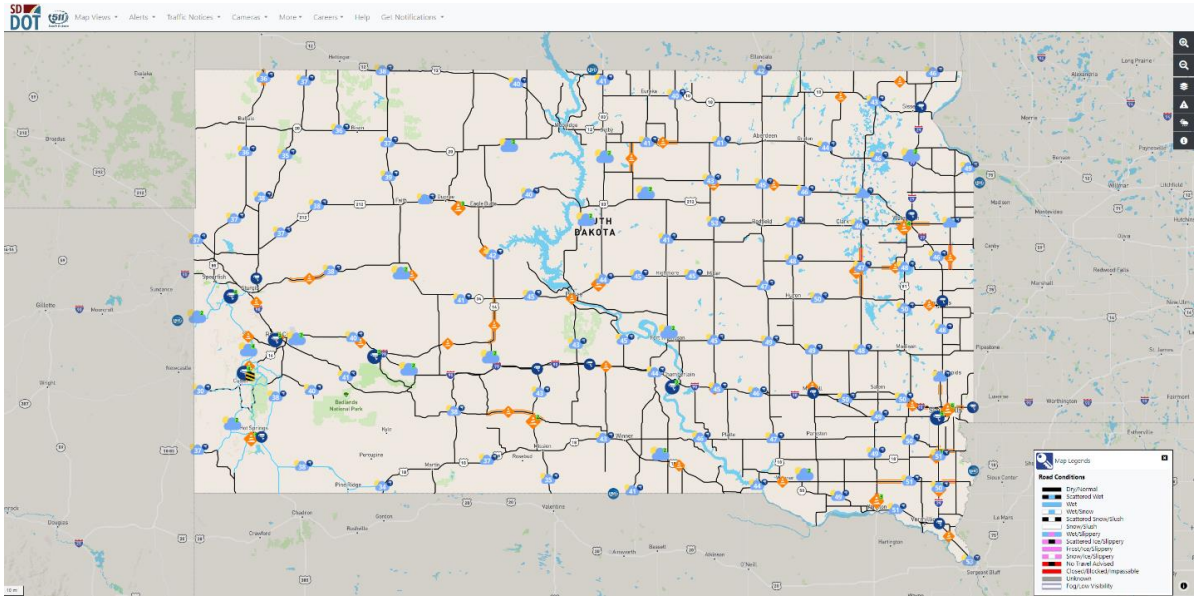


Figure 12: SDDOT SD511 Website

Types of traveler information found on SD511 include:

- **Traffic Speeds,** which are displayed by color-coding roadways to indicate if congestion on a route is low, moderate, heavy, or severe.
- **Road Conditions,** which inform drivers of weather-related road conditions (such as "wet," "snow," and "ice") and indicates if roads are not advised for travel or closed or otherwise impassable.
- **Commercial Vehicle Restrictions,** which indicate weight or other commercial vehicle restrictions by icons and color-coded roadways. Temporary restrictions have pop-up information indicating when the restrictions are in place.
- **Directions,** which users of the site can receive by entering a start and finish location and choosing "traffic," "walking," or "cycling" for mode of transportation.
- **Events,** which are manually entered items expected to impact traffic speed or safety for a significant length of time. Items such as construction zones or scheduled events can be added to the map ahead of time. Unplanned items, such as incidents or disasters, are added to the map when operations staff become aware of their presence and the impact warrants notifying the public. Events include incidents, construction, commercial vehicle operations restrictions, disturbances, disasters, obstructions, and scheduled events.

- **Weather Information,** which includes precipitation, air temperature, wind speed, National Weather Service (NWS) alerts, and visibility. NWS Alerts indicate areas where severe weather is forecasted by the National Weather Service. Environmental Sensor Stations show the air temperature, dew point, relative humidity, wind direction, wind speed, wind gust speed, precipitation type, and precipitation intensity at each site. ESS with cameras also show static images captured at the site, updated every five minutes.
- **Traveler Information,** which includes the location of traffic cameras, ports of entry, rest areas, and neighboring states' 511. Selecting a traffic camera allows the user to scroll through static images captured by the camera from several angles, updated every five minutes. Ports of entry show the location and name of the ports with a link to South Dakota's truck information website. Rest areas include the location as well as facilities available at the site, such as picnic areas, vending machines, and truck parking. Neighboring States' 511 includes links to adjacent states' 511 websites.

4.2.2.2 Dynamic Message Signs

SDDOT owns, operates, and maintains fixed DMS as well as many portable DMS used to supplement fixed signs during temporary traffic events such as construction. Figure 13 shows a DMS installed along I-29 just north of Brookings.

SDDOT staff use vendor-supplied software to update DMS with information and advisories such as weather warnings, road closures, and crashes or delays.

Figure 13: SDDOT DMS

4.2.3 Road Weather Management

SDDOT uses a complex system of specialized equipment, technology, and personnel specifically trained for road weather management. Additionally, some facets of winter highway maintenance are dictated in State codified law. To address changes effectively and efficiently, SDDOT uses a variety of technologies to gather data, inform travelers, and manage equipment.

4.2.3.1 Winter Maintenance

Normal winter maintenance operations occur from 5am to 7pm during storms when conditions allow. SDDOT Highway Maintenance Supervisors have the authority to suspend winter maintenance operations when conditions are expected to become too hazardous. Routine extended hours of winter maintenance are also performed on some of the highly traveled Interstate routes, and around Sioux Falls and Rapid City. After-hours operations are at the discretion of the SDDOT Highway Maintenance Supervisor. Operations may continue after 7pm if highway and traffic conditions warrant, if progress can be made, and if staffing is available.

4.2.3.2 Road Weather Information System

The SDDOT maintains ESS throughout the state, which feed information to SD511 and to the Maintenance Decision Support System (MDSS), which is particularly useful for SDDOT maintenance staff responsible for winter weather operations. ESS stations collect air temperature, dew point, relative humidity, wind direction, wind speed, wind gust, precipitation type and precipitation intensity. Most

ESS are also equipped with a CCTV camera, which captures still images of conditions that are also shared on SD511 and MDSS. Information collected by an ESS is shown in Figure 14.

Winter weather information is communicated to the public through several media including 511, ClearPath 511 (email and text alerts), social media, DMS, and at kiosks stationed in rest areas and ports of entry. The SD511 website, application, and kiosks are automatically updated with information, such as NWS alerts, forecasts, and current weather conditions. Imagery from CCTV cameras is updated automatically every five minutes, allowing users to see road conditions.

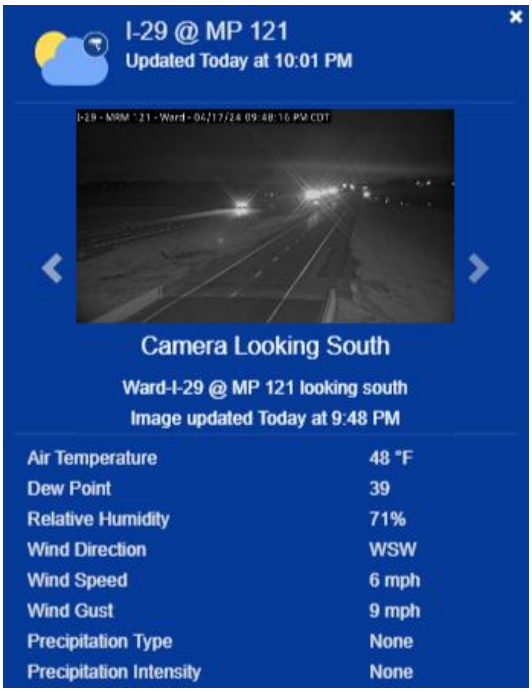


Figure 14: Information from SDDOT ESS

4.2.3.3 Maintenance Vehicle and Equipment Tracking

Some snowplow trucks are equipped with mobile data collector (MDC) units that capture data from plow blade sensors, air and road temperature sensors, GPS, and spreader controllers. The MDC communicates this information via cellular modem to the MDSS to ensure its analysis considers the effect of maintenance already performed. The MDSS returns weather and road condition forecasts and recommendations for plowing and chemical applications. For the 2023 – 2024 winter season, SDDOT had over 200 snowplow trucks with the MDSS system installed. SDDOT plans to have automatic vehicle location (AVL) installed on all full-time snowplow fleet trucks by the 2024 – 2025 winter season. There is potential to expand AVL deployment to other maintenance and construction vehicles.

4.2.3.4 Maintenance Decision and Support System

SDDOT processes and distributes environmental information and data to detect environmental hazards and coordinate effective responses with internal and external partners. The MDSS pulls and analyzes weather and road condition data from ESS, in-vehicle snowplow equipment, and feedback from operations staff and recommends material to use, the application rate, and timing. The system

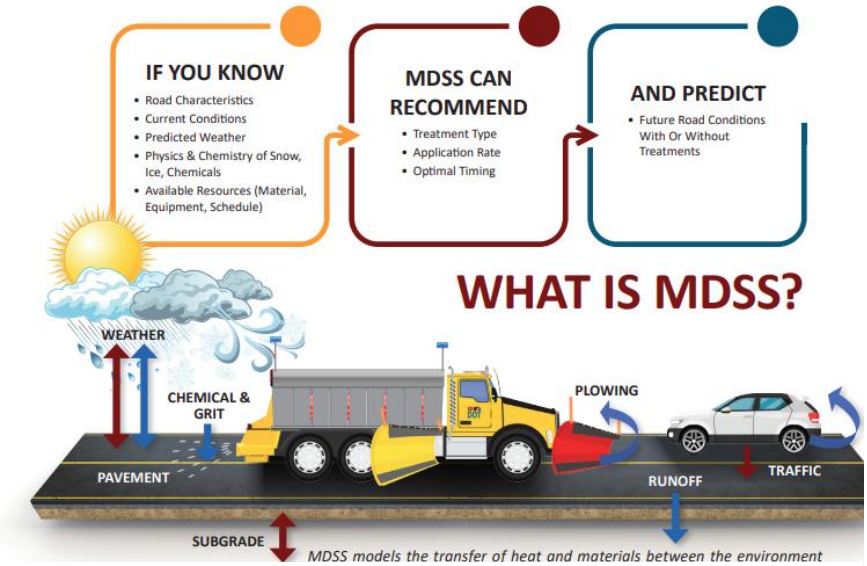


Figure 15: MDSS Overview

also tracks maintenance activities and resource use throughout a winter storm. An overview of MDSS is shown in Figure 15.

4.2.4 Maintenance and Construction Information Management

SDDOT is responsible for maintaining SDDOT property and facilities. This includes maintaining roadways to ensure that they remain in a state of good repair and that pavement is clear of snow, ice, debris, and other hazards. SDDOT is also responsible for maintaining SDDOT equipment such as ITS field devices and for routine maintenance of state right-of-way. SDDOT uses several technologies and systems to assess real-time conditions and to complete activities in an efficient manner.

4.2.4.1 Roadway Maintenance and Construction

SDDOT supports numerous services for scheduled and unscheduled roadway maintenance and construction. Maintenance services include pavement patching, guardrail repair, landscape maintenance, hazard removal (roadway debris and dead animals), routine maintenance activities (roadway clearing and grass cutting), and repair and maintenance of both ITS and non-ITS equipment. Environmental information processed by the Department's MDSS is used to aid scheduling maintenance and construction activities.

From April to November, normal roadway operations are impacted by construction activities throughout South Dakota. Construction operations often result in lane closures, changes to traffic patterns, detours for all traffic, or detours for truck traffic. These impacts can last anywhere from a few hours to a few months, and often need to be planned across multiple construction projects and multiple local agencies. Alerting drivers to these impacts on their route can be complex but is very important.

In the case that maintenance operations or construction projects affect traffic conditions, the SD511 system provides updated travel speeds along SD roadways. When construction or maintenance is expected to have significant traffic impacts, SD511 is updated to show the location and basic information about the maintenance or construction work being done and any resulting travel restrictions, as shown in Figure 16.

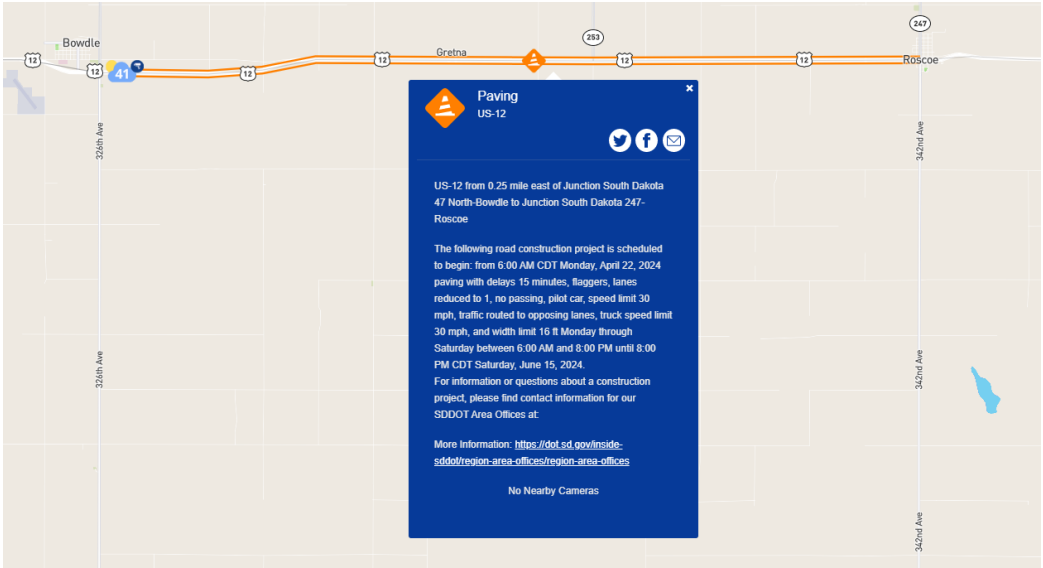


Figure 16: Construction Work Shown on 511

4.2.5 Special Event Management

The SDDOT supports special events, primarily with traffic management for the Sturgis Motorcycle Rally.

4.2.5.1 Sturgis Motorcycle Rally

The largest special event traffic management efforts in the state take place during the Sturgis Motorcycle Rally, an annual event that attracts around 500,000 visitors each year. The SDDOT and SDHP partner to support traffic operations for events and typical traffic in the area.

Prior to the event, a traffic management plan is put together to support the high volume of vehicles. Staff and equipment are dedicated to the area during the event. During the event, SDHP gives SDDOT direct access to its CAD software, reducing delays in communication between the two agencies. Temporary ITS equipment is deployed in the area, making use of resources like portable signals (as shown in Figure 17) and DMS to communicate information and route traffic. Traffic operations such as queue detection systems not commonly used within the state are deployed during the event due to the increased need.

Figure 17: Portable Signals for Sturgis Motorcycle Rally

4.2.5.2 Other Special Event Management

Events other than the Sturgis Motorcycle Rally rarely have large SDDOT involvement. The size of these events combined with the limited resources of the SDDOT do not warrant the same level of response. Traffic management is typically led by local agencies with coordination between the SDDOT and other agencies for these events rarely exceeding daily practices.

4.2.6 Public Safety and Incident Management

SDDOT helps to manage both unexpected incidents and planned events to minimize impacts to the transportation network and to enhance traveler safety in the appropriate area and/or region.

4.2.6.1 Incident Response

Traffic incidents are typically addressed by the South Dakota Department of Public Safety, specifically SDHP. If incidents are caused by inclement weather or are expected to have significant impacts to traffic, SDHP can alert SDDOT staff so they may take appropriate action. SDHP may also request SDDOT assistance for incidents on Interstate highways in Sioux Falls or Rapid City, or when fatal crash investigations require traffic control.

4.2.6.2 Emergency Call-Taking and Dispatch

The South Dakota Office of Emergency Management receives 911 calls and dispatches emergency responders. CAD systems are used to manage the SDHP fleet. Efforts to link the SD511 system with emergency response CAD systems were initiated in 2016, but the project was not completed due to technological problems. The work is scheduled to complete in early 2025.

SDHP officers who respond to a crash or incident and believe it will have a significant impact on traffic or safety in the area can contact SDDOT staff, who can then manually update SD511 with relevant information. Updates can only be made during typical SDDOT staff working hours and may take a long time to update the system. As such, SDHP typically only reports severe incidents with major or lengthy traffic impacts to the SDDOT.

4.2.7 Commercial Vehicle Operations

SDDOT assists with commercial vehicle operations by deploying roadway sensors to detect oversize/overweight vehicles. In addition, information is shared via SD511 for commercial vehicles to better plan their trips. Operations Support staff enter temporary restrictions for maintenance or construction projects and spring load limits into the permitting system used by SDHP's Motor Carrier Services group. SDDOT Region and Area Engineers must approve special permits for commercial vehicle movements in the Black Hills region during the Sturgis Motorcycle Rally.

4.2.7.1 Electronic Screening Systems

SDHP operates several weigh stations for commercial vehicles throughout the state. Traditional weigh stations have facilities to inspect vehicles for compliance with commercial vehicle restrictions and policies. Electronic screening systems at Interstate ports of entry and other key locations integrate weigh-in-motion scales, license plate readers, CCTV cameras, over-height detectors, tire anomaly sensors, and infrared brake heat sensors to automatically detect safety violations or concerns of moving trucks as shown in Figure 18.

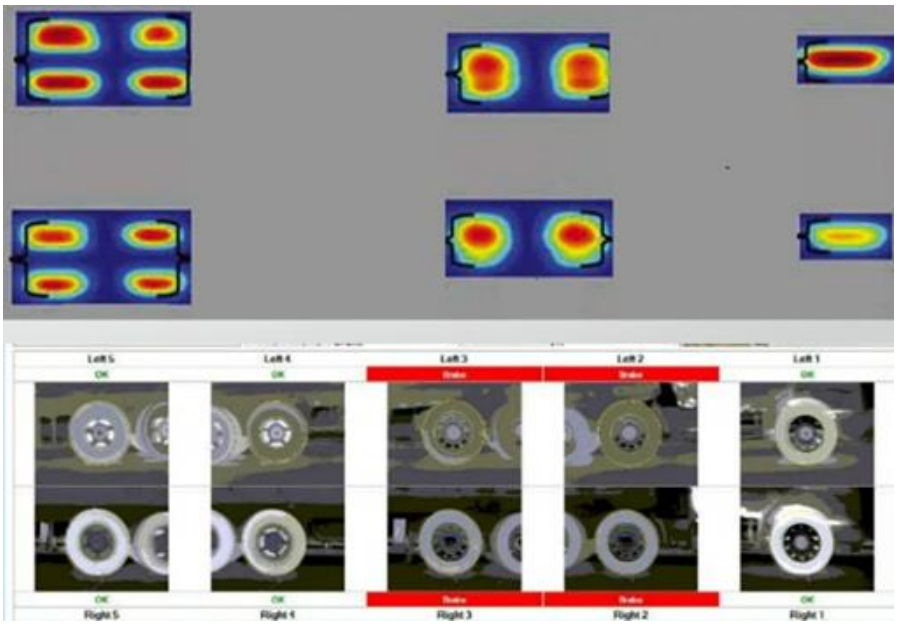


Figure 18: Tire Anomaly and Thermal Brake Sensors

Several private companies offer in-vehicle technology compatible with State inspection practices to communicate information to port of entry or weigh stations to help expedite screening processes.

4.2.7.2 Truck Oversize/Overweight Travel Planning

Restrictions on commercial vehicles are made available for drivers in several locations. SD511 includes a layer that displays the weight limits for roadways (see Figure 19). Temporary restrictions are flagged on the map and can be selected for more information about the weight and dimension limits and when restrictions apply.

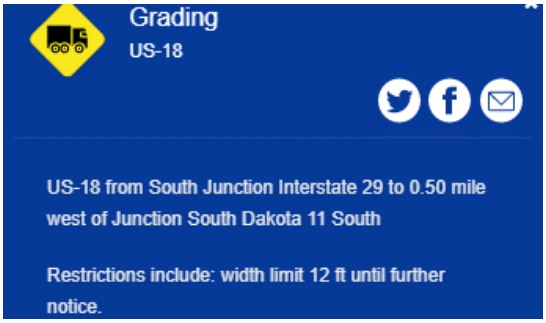


Figure 19: Commercial Vehicle Restriction Shown on SD511

Restrictions and other commercial vehicle information are also made available on the South Dakota Truck Info website https://sdtruckinfo.sd.gov managed by the SDDOT, the SD Department of Revenue, and the SD Department of Public Safety. Haulers obtain permits for oversize/overweight loads and for a variety of other special circumstances through the South Dakota Automated Permitting System, which is provided by SDDOT's ITS Program and used by SDHP's Motor Carrier Services group.

4.2.8 Data Management

Vehicle detectors, ESS, CCTV cameras, and many other ITS devices collect and store data. However, except for MDSS, this data is rarely analyzed or stored long term. No central repository for data exists, and maintaining large volumes of data can be costly and time-consuming.

4.3 Traffic Operations Center Functions

SDDOT already performs many traffic operations functions within the state without a TOC. Some do not explicitly require a TOC, nor do many other traffic operations the SDDOT does not currently perform. However, as discussed in the literature review, states consistently find that TOCs improve the efficiency and effectiveness of these operations. The ability of a TOC to continually improve system performance, coordination, communications, strategies, and responses are summarized in Figure 20.

The function of every TOC differs depending on the needs and resources available to each agency. A TOC provides many new opportunities for the SDDOT, but not all will fit with the SDDOT's greater goals and means.

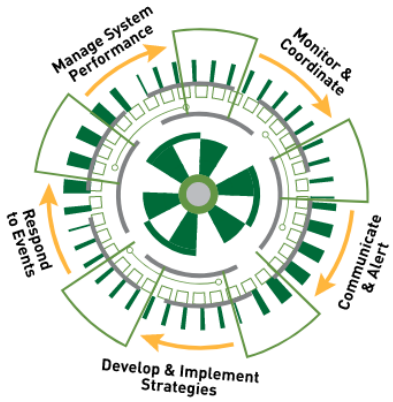


Figure 20: Enhanced TOC Capabilities

Graphics and information included in Appendices A and B depict the various existing and future traffic functions that could be performed by the TOC along with example operational processes. These appendices are not intended to list all the required functions and services a TOC must offer. Rather, the SDDOT will determine which to pursue for this initiative. Some functions may not be suitable for the state when the TOC is first opened but may be explored in the future.

5.0 PHASE III – ALTERNATIVES ANALYSIS

5.1 Build versus No-Build Analysis

Creating a TOC for South Dakota would allow the SDDOT to deploy many new traffic management strategies while taking existing operations to the next level. The functions of a TOC include:

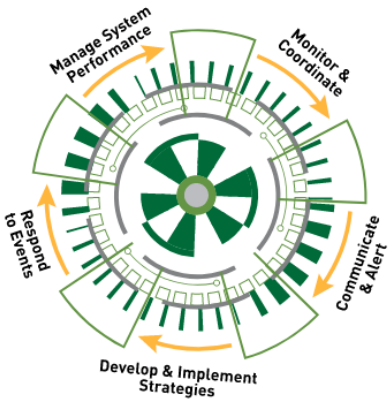


Figure 21: Functions of a TOC

- Managing System Performance – Addressing daily, unpredictable events such as weather or crashes to keep transportation systems throughout the state reliable
- Monitoring and Coordinating – Working with first responders to improve roadway safety and save lives
- Communicating and Alerting – Notifying partners and the public of delays or concerns and directing them with traffic management information
- Developing and Implementing Strategies – Collecting data, identifying patterns, deploying new solutions, and evaluating the performance of actions taken
- Responding to Events – Controlling and overseeing large volumes of traffic from planned events, such as the Sturgis Motorcycle Rally

This chapter describes the expected benefits of a TOC and compares the benefits and drawbacks of five potential alternatives.

5.1.1 Manage System Performance

One of the primary functions of a TOC is to improve transportation system reliability and efficiency when the system is impacted by weather, crashes, maintenance, or special events. Most delays come from non-recurring, unpredictable events that, while common, cannot be quickly addressed without staff and technology ready to respond on a case-by-case basis.

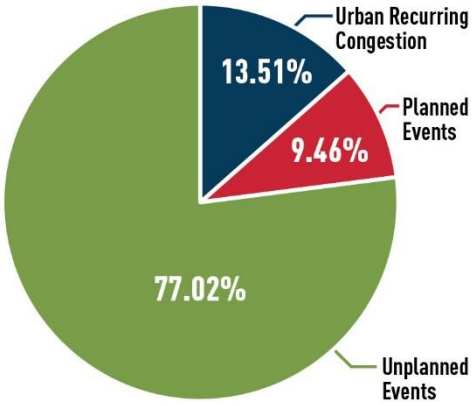


Figure 22: Causes of Delays

Traffic delays affect all travelers, but delays for freight vehicles have a massive economic impact. Freight travel makes up 23% of statewide traffic on Interstate highways and other principal arterials. The FHWA has found that freight carriers value transit time at $25 – $200/hour, which can increase by 50% -- 250% during unexpected delays (Federal Highway Administration 2020). The cost of congestion continues to increase. From 2016 – 2021, the cost of truck congestion rose 27% while the Consumer Price Index (a measure of inflation) only rose 12.9% (Short and Leslie 2023). In 2022, the FWHA estimated South Dakota to have an average freight delay of 198 truck hours per mile on National Highway System (NHS) roads. In the urban areas of Rapid City and Sioux Falls, these delays increase to 791 and 753 truck hours per NHS mile, respectively. In total, for 2022, the state had almost 1.5 million truck delay hours within the state on NHS roadways (Federal Highway Administration n.d.).

Providing reliable, efficient travel throughout South Dakota is essential to freight operations and the state economy. Providing competitive travel times ensures that freight continues to operate throughout the state and goods are delivered on a timely and cost-effective schedule.

Outside of freight, maintaining the health of a transportation network means improving travel reliability, safety, environmental impact, and users' overall satisfaction of roadways. With a TOC, SDDOT can begin collecting and analyzing data on overall system performance to learn and enhance their network. During accidents, inclement weather, events, or maintenance, staff can identify and monitor events faster, take appropriate action, and ensure that daily transportation operations are operating as smoothly as possible.

5.1.2 Monitor and Coordinate

TOCs play a pivotal role in identifying and responding to crashes. In the case of serious crashes with life-threatening conditions, every moment of incident and response time matters. When a person stops breathing, they have less than 15 minutes before irreversible brain damage sets in and the injury results in death (University of Michigan Transplant Center 2010).

Figure 23: Timeframe of Brain Damage

In rural areas, where incidents are less likely to be quickly seen and reported by other travelers and where hospitals are farther away, reducing response time is particularly challenging. In Sioux Falls and Rapid City, response times averaged under 30 minutes between 2020 and 2022. In rural areas, agency response can take hours rather than minutes. South Dakota, a largely rural state, had an overall average response time of over 100 minutes.

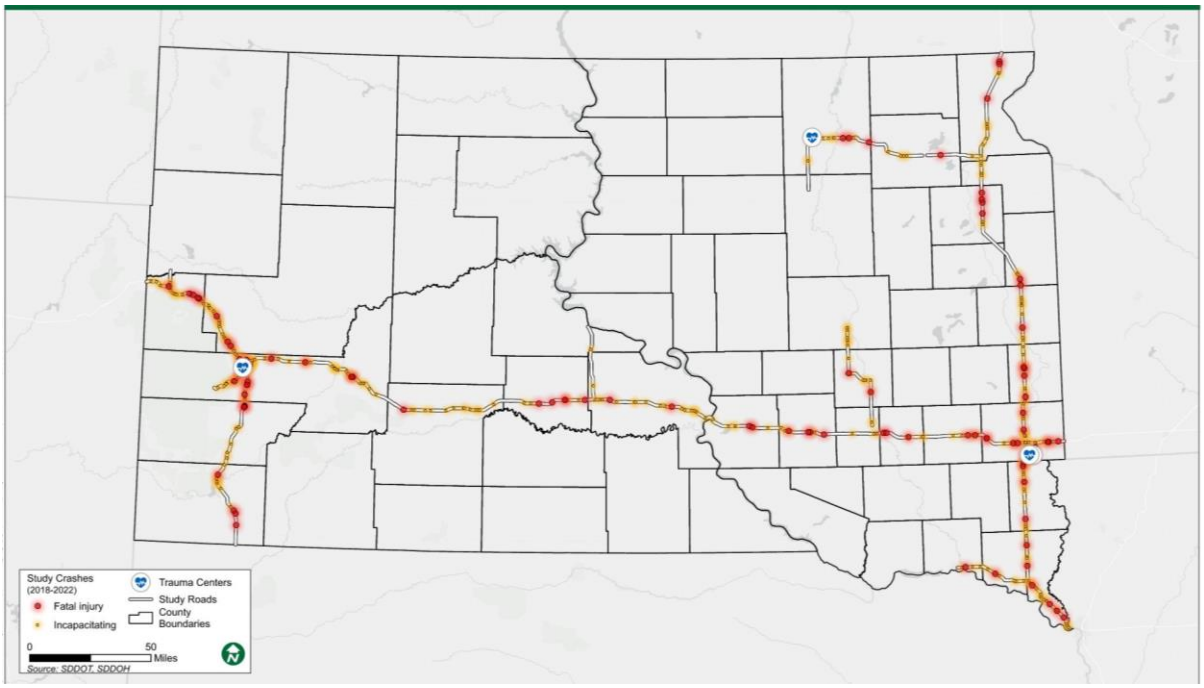


Figure 24: Location of Fatal & Incapacitating Crashes and Trauma Centers in South Dakota

TOCs have a well-established history of reducing incident identification and response time. The Iowa DOT found an average reduction of 10 minutes of incident response time with their fully operational TMC. Staff from the Wyoming DOT reported an average 50% reduction in clearance times after opening their TMC.

The impact on identification and clearance times is partially dependent on the scale and resources of a TOC. A 24/7/365 TOC would be able to detect and respond to more incidents than one with limited hours. However, that is not to say that a TOC that could only function during business hours would not have major effects. Within the state, over a quarter of crashes occur during typical business hours. Many states, including the Wyoming DOT, began with TOCs staffed only during business hours, only to transition to 24/7 coverage as their needs and resources evolved.

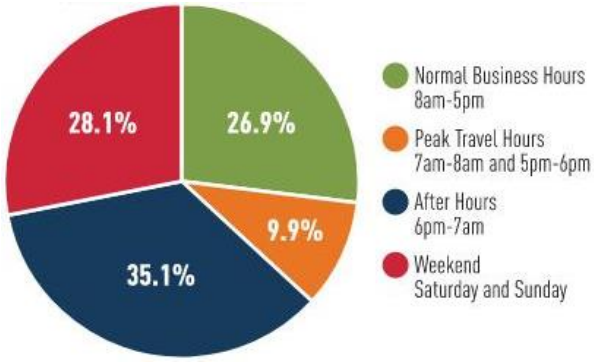


Figure 25: Crashes by Time of Day

If incidents occur in areas with surveillance cameras, staff may be able to detect them by monitoring camera feeds. Larger or future deployments of the TOC could make use of other monitoring tools, which may be as simple as additional surveillance cameras or as complex as data collected from connected vehicle sensors or crowdsourced from other travelers.

Many incidents can be resolved quickly and internally by TOC staff employing established Standard Operating Procedures (SOP), such as using a DMS to warn drivers of a closed shoulder ahead. Other events require coordination with outside agencies, such as SDHP and other emergency responders.

In these instances, the TOC may simply call 911 and report the situation. If the TOC shares the same location as emergency responders, information sharing may take place in person. During the Sturgis Motorcycle Rally, the SDHP allows the temporary TOC staff read access to their CAD system so incidents can be quickly assigned to responding SDDOT staff based on location and availability. Integrating SDHP CAD with traffic operations has long been a goal of SDDOT and SDHP.

Partnerships between the DOT, SDHP, and South Dakota Office of Emergency Management are long-standing and successful. During crises like large floods that require evacuations, these agencies must come together quickly to deploy life-saving strategies. Organizing traffic operations to a single point of contact would streamline the processes of these partnerships when time can be a matter of life or death.

5.1.3 Communicate and Alert

While emergency detection and response are the highest priorities for a TOC, they are far from its only goals. Not all incidents are crashes, and not all crashes include serious injuries or fatalities. However, long clearance times pose other risks and consequences. From 2020 to 2022, collected data on crash rates on State roads in South Dakota revealed an average clearance time of over 100 minutes. Figure 26 shows illustrates these average clearance times, broken down by the type of incident.

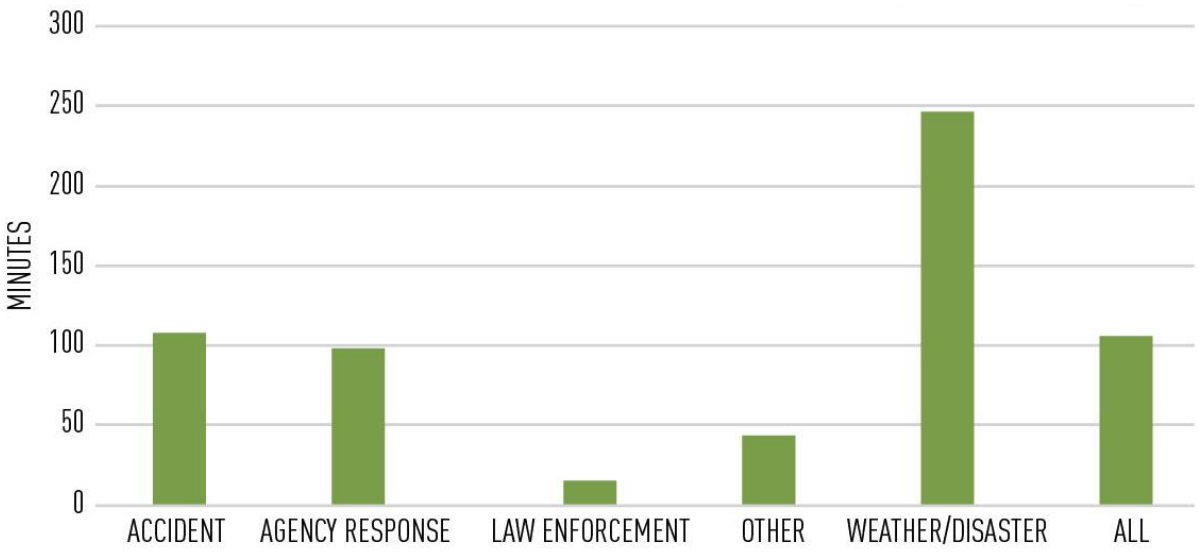


Figure 26: Average Incident Clearance Time (2020-2022)

According to the FHWA, every additional minute of clearance time results in a 2.8% increase in secondary crash potential (Federal Highway Administration 2020). Similarly, each additional minute of blockage on a freeway lane results in an additional four minutes of total delay (Federal Highway Administration 2020). In addition to safety and delay concerns, long clearance times lead to long idling times and increased pollution. Longer delays and more incidents negatively impact elements of the economy tied to the transportation network, such as the freight industry.

Figure 27: Secondary Crash Potential

Just as a TOC serves as a hub to communicate with first responders, it is also responsible for alerting and involving other players, such as partner agencies and the public. When an event occurs, TOC staff may notify tow trucks or DOT maintenance staff to help clear the area. Outside of clearing events, TOC staff can alert partner agencies such as city, county, and adjacent state DOTs, who may choose to take their own monitoring or response actions.

The TOC can communicate with the public about impacts to transportation. TOC staff can quickly update DMS upstream of the incident to route traffic or simply alert drivers to the upcoming threat. A staffed TOC can also update SD511 more quickly and more often than other SDDOT staff can. The lack of integration between SDHP's CAD system and SD511 has hindered attempts to communicate information on crashes to the public. Between 2018 and 2022, over 4800 crashes were recorded within the state. During the same period, only 95 accidents—less than 2% of these accidents—were entered into SD511.

Figure 28 shows a bar graph of 511 entries from 2018-2022, broken down by category. The construction category makes up most entries, as these are typically scheduled events that can be entered ahead of time. Events that do not have advance notice, are short-lived, or take place outside of typical working hours are more difficult or not worth adding to the 511 system.

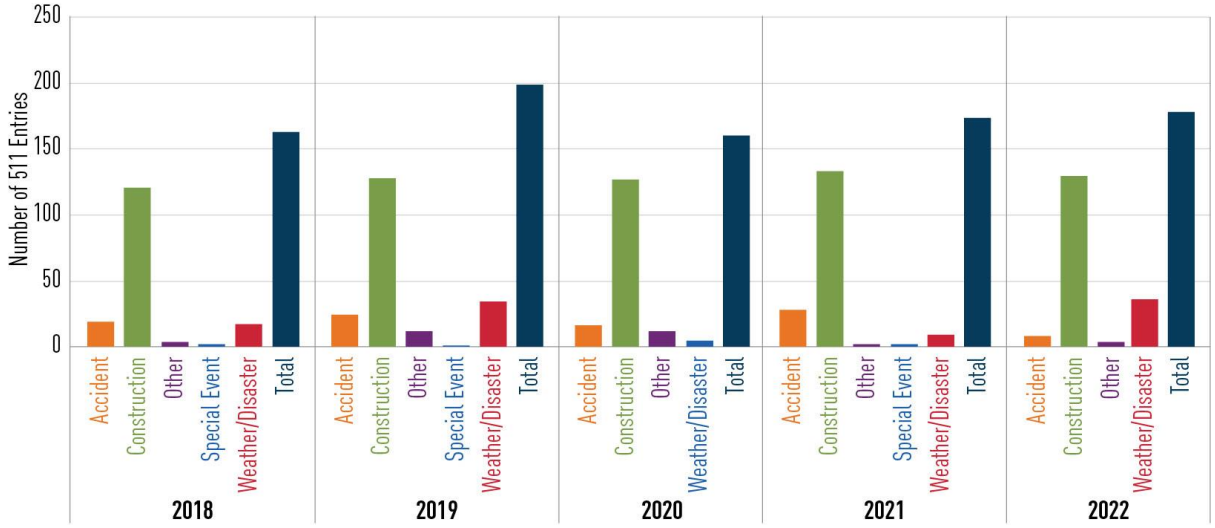


Figure 28: SD511 Journal Entries, 2018-2022

Aside from the increase of events that can be entered into SD511, a TOC has the potential to open doors for new kinds of communication between the public and the DOT. Many states use their 511 system to send push notifications to users to warn of upcoming hazards like work zones or snowplows. Other technology, such as the Wyoming DOT's 511 application, grants the public the ability to notify the DOT about concerns, including serious safety risks such as a car crash in a rural area and maintenance issues like debris or roadkill.

This level of communication is not feasible without a TOC. These functionalities may be too resource- or cost-intensive for the SDDOT to deploy any time soon, but the creation of a TOC is the first step toward many further technology improvements and can provide the foundation for future expansion when the DOT is ready.

5.1.4 Develop and Implement Strategies

As the TOC grows and develops over time, so will its strategic goals and initiatives. Monitoring and responding to incidents allow for data collection and metrics to strengthen the TOC and traffic operations. The existence of a TOC also opens the door for technologies that would be difficult or impossible to use without staff and resources to deploy them.

Currently, transportation data collected by the DOT is limited. For example, while it is known that 39% of crashes within the state involve inclement weather, there is little data that would show what technologies or strategies are most successful at combating these crashes. Similarly, SDDOT does not analyze data on secondary crashes. A TOC can assist with data collection and entry to improve the quality and quantity of this information.

A staffed TOC can also make use of data already collected by the DOT in new ways. Vehicle detectors already collect information on vehicle speeds, but it is not typically used in real-time. TOC staff monitoring the network may be alerted when an area suddenly experiences a sharp reduction in speed. Staff can use CCTV in the area to see if they can determine the cause and monitor the situation resolves.

Many TOCs have formed partnerships with universities to take their data analytics to the next level. Research groups at universities such as South Dakota State University, the South Dakota School of Mines and Technology, and the University of South Dakota could be given access to data collected by

the TOC. Universities can analyze data in ways DOTs typically cannot, due to lack of resources or advanced tools like Artificial Intelligence (AI) modelling.

These partnerships are often used to evaluate the effectiveness of a strategy. Pilots of new technologies can be evaluated on metrics such as crash rates, speed data, or delay times. More complex systems, such as VSL, can be studied to see which factors have the largest impact. The TOC may find that only certain weather conditions benefit from lowering the speed limit or that drivers only respond to a lowered speed limit if it is above a certain value. Many grants and federal funding agreements require metrics to be collected.

5.1.5 Respond to Events

Many of the largest traffic management needs come annually with the Sturgis Motorcycle rally. During this time, the DOT and SDHP partner to form a temporary TOC to handle large volume of visitors to the event, which draws around 400,000 to 700,000 attendees (City of Sturgis, South Dakota 2023). During this time, SDHP makes its CAD system readable to DOT staff. Traffic management during this time employs tools such as queue warning systems not typically used by the DOT at other times of the year.

With South Dakota's current population at less than one million people (United States Census Bureau n.d.), managing the rally is a massive undertaking. In addition to the sheer size of the rally, whose attendees consist of over half the normal South Dakota population, riders travel on individual motorcycles from many directions, converging on the same, small area. Managing an event of this size has given the DOT a blueprint for a successful TOC that can be adapted statewide.

Currently, the DOT does not do event traffic management outside of the Sturgis Rally, but multiple strategies could be employed. While the SDHP CAD system is not fully integrated with the TOC, the agencies could temporarily grant access to TOC employees during similar smaller events, such as the LifeLight music festival, which draws around 25,000 people near Sioux Falls (LifeLight n.d.). A TOC operating under typical business hours may choose to extend working hours during the event. Smaller events, such as concerts or football games, could use techniques such as temporary queue warning systems with staff and resources at hand to quickly deploy.

5.2 Potential Build Alternatives

5.2.1 Key Descriptors

Key descriptors used to characterize the development features for a TOC in South Dakota are described below.

5.2.1.1 Functionality

While the functionality of a TOC can vary by region, state or facility, the candidate functions identified for the SDDOT TOC are described below. The initial development of the TOC does not require all identified functions to be developed and deployed initially. The development can evolve using a building block approach where functionality is expanded over time. Additional functionality may be necessitated by evolving operational needs or mandates. As an example, in New York State, individual regional TMCs are required for the first time by state law to support automated work zone speed enforcement. This functionality was not envisioned when the TMCs were planned and developed.

Potential functions envisioned for an SDDOT TOC were identified and discussed in the literature review and include:

- Road Weather Management – Involves predicting and preparing for weather changes, identifying weather-related threats to the highway system, and proactively responding to them. The TOC can help warn travelers of changing weather and roadway conditions, actively control and manage ITS infrastructure, and initiate responses and tactics in real time by:
  - pre-treating roads with anti-icing materials
  - pre-positioning snowplows for de-icing, sanding, or plowing
  - employing advanced freeway management operational strategies such as variable speed limits
  - accelerating incident response
  - disseminating real-time information to travelers and operational stakeholders (Federal Highway Administration 2024)
- Special Event Management – A special event is a public activity with a scheduled time, location and duration that may impact the normal operation of the highway system due to increased travel demand or reduced capacity attributed to event staging. The most notable special event in South Dakota is the Annual Sturgis Motorcycle Rally.
- Traffic Management – The process of applying operational strategies and technologies to manage traffic or enhance the safety, mobility, and reliability of the transportation network.
- Traveler Information – Using a range of systems, strategies, and media to update travelers on current roadway conditions, including delays, incidents, weather-related messages, travel times, emergency alerts, and alternate routes. (Federal Highway Administration 2022)
- Public Safety Incident Management – The planned and coordinated multi-disciplinary process to detect, respond to, and clear traffic incidents to restore traffic flow as safely and quickly as possible.
- Commercial Vehicle Operations – Provision of truck related pre-trip and real-time information, including parking availability information, viable routes, and roadway conditions. The TOC may also facilitate the exchange of vehicle restriction information, permitting information, inspection station locations and procedures, and weather advisories.
- Maintenance and Construction Information Management – Informing the traveling public and other stakeholders of construction and maintenance activities and impacts, coordinating these activities with other impacted jurisdictions, ensuring work zones are set up to meet appropriate standards, and coordinating maintenance and construction activities with other jurisdictions when these activities could impact the operation of SDDOT-operated roadways.
- Data Management – Collection, compiling, processing, and archiving of data to support day-to-day transportation operations activities, and other analytical activities (e.g., transportation planning and performance monitoring and assessment).

5.2.1.2 Facility

TOC functions can be housed in a range of facility types, with or without co-location with stakeholders such as law enforcement, and with varying levels of remote access. Determination of the facility, type, location, and occupancy can be driven by a range of factors including required functionality, available capital resources, and space availability in existing government facilities. TOC facility organization and configuration options to be considered by SDDOT are:

- Remote – Remote ATMS access only. TMC operations staff are physically distributed
- Temporary physical space During Sturgis Rally – Can support operations independently, or collaboratively with another SDDOT TOC facility

- "Desktop" facilities in key locations (eg, Sioux Falls and Rapid City) – Remote operations at a limited number of locations where TOC operations staff can work collaboratively with other regions within the state
- Virtual remote access for each SDDOT Region – Remote operations where each region has access to command and control of TOC functions
- Centralized core location – Centralized statewide TOC where functions are housed in one location without major development and construction activities
- Fully built out centralized physical space – Centralized statewide TOC where a physical space is developed specifically to house TOC functions
- Co-location with South Dakota Highway Patrol – Centralized statewide TOC where a physical space is developed specifically to house TOC functions and the SDHP

5.2.1.3 Workforce Structure and Requirements

Meeting the operational objectives of any TOC is predicated on the ability of operations staff to perform tasks correctly, effectively, and efficiently. Defining the correct staffing levels and skill sets is also a critical factor in meeting the TOC operational objectives. Workforce requirements are defined in the following labor categories:

- Full-Time Staff (with expanded skill sets) – Includes SDDOT TOC operators, SDDOT TOC supervisors, and the SDDOT TOC operations manager
- Part-Time Staff (with expanded skill sets) – Includes staff who provide unique functional expertise, such as work zone coordination or performance reporting
- Flex Staff – SDDOT staff used to support varying administrative and operational needs of the TOC
- Flex Staff for special events and major adverse weather conditions – Operations staff who periodically augment operations staff assigned to the TOC
- Part-Time repurposed SDHP Staff – Staff designated by SDHP to support SDDOT TOC operations

5.2.1.4 Coverage Area and Hours of Operation

Coverage area and hours of operation define the roadway network (e.g., statewide focused on Interstate highways, and four-lane expressways) the SDDOT TOC will monitor and operate, and hours of operation (e.g., 24x7x365).

5.2.1.5 Estimated Costs

Costs are estimated in terms of:

- Capital – Required to design and construct the TOC, including costs of new equipment and furniture
- Annual/Recurring – Fees for services required to sustain operations of the TOC, including items such as electric or other utility bills and software licenses
- Staffing – Costs of operating the TOC, estimated for both self-performed and outsourced staffing

All three costs are estimates based on comparable operations centers nationally. Unit costs or cost ranges are estimated based on desired high-level functionality identified during the initial planning phase of this effort. As functionality, user needs, and requirements are defined in greater detail it will be necessary to reexamine and update cost estimates. Different technical approaches may be taken in

the development of the TOC (e.g., cloud-based resources versus on-premises resources) and will need to be analyzed through further development efforts.

Estimated unit costs used to calculate capital costs for each alternative are included in Table 1. Some unit costs are presented as ranges. These items are one-time costs for each alternative but are expected to change depending on the complexity and needs of each TOC model. These costs are intended for planning purposes only based on a comparable TOC and would be refined during future phases of this effort.

Similarly, estimated recurring annual costs are included in Table 2.

To assist in estimating staffing costs, generic labor categories are defined based on typical TOC job responsibilities and hourly pay ranges defined in Table 3. As TOC alternatives are selected and further refined, it will be necessary to re-examine staffing levels and desired TOC functionality to determine whether updated estimates are required. Updates can include both increased staffing levels (e.g., additional operators) and additional labor categories not initially identified (e.g., construction and maintenance coordinators).

For comparison purposes, labor costs are estimated for outsourced services and for services self-performed by SDDOT. Outsourced labor rates are fully burdened (e.g., inclusive of labor rate, overhead, and fees) and reflect what SDDOT would be invoiced by a contractor. Costs of self-performed labor include SDDOT's payroll additive for fringe benefits.

Table 1: Capital Unit Costs

Item	*Unit Cost or Range*	*Notes*
TMC Workstation (Centralized)	$5,500	Computer, monitors, and accessories for an advanced TOC space
TMC Console (Centralized)	$2,000	Chair and desk/console for an advanced TOC space
Temporary Workstations for Sturgis Rally (assumes using existing desk or table)	$2,500	Technology and equipment such as computers and monitors for temporary use during the Sturgis Rally
"Desktop Facilities" – Workstation	$2,500	Computer, monitor(s), and accessories that resemble a typical desk setup in a DOT building rather than specialized TOC equipment
"Desktop Facilities" – Console	$1,000	Chair and desk that resemble a typical desk setup in a DOT building rather than specialized TOC equipment
Virtual Remote Access – workstation	$1,500	Computer, monitor(s), and accessories for a virtual workspace
Radio Console	$5,000	Radio equipment for use with emergency services
Desktop Phone	$1,500	Desktop phone to be used by TOC operators
Display Wall	$20,000	Large screen(s) mounted on wall visible to all staff within the TOC
Servers / Deployment	$225,000 – $675,000	Platforms and software for storing TOC data
Network / Firewall / Data Security	$100,000 – $500,000	Software and services to support TOC operations and secure information
ATMS Software	$75,000 – $150,000	Software to monitor and control ITS and other traffic devices
Video Management Hardware/Software	$50,000 – $150,000	Software and hardware used to manage the display wall and associated video infrastructure
Weather Software	$75,000	
Radio Software	$130,000	
Installation/Integration	$100,000 – $500,000	Cost to install and/or integrate the physical and virtual components of the TOC

Table 2: Annual Unit Costs

Item	*Unit Annual Cost*	*Notes*
ATMS Software	$85,000	Subscription/licenses for ATMS software
ATMS Server	$1,000	
511 Phone System	$170,000	Subscription/support fees for the SD511 phone system
Weather Software	$50,000	Subscription/license fees for weather software
Computer Aided Dispatch Access	$30,000	Subscription/support fees for CAD access and integration with TOC systems
Travel Info Map Maintenance	$30,000	Subscription/support fees for the SD511 website and mobile applications
DOT GIS WEB Server (Travel Map)	$2,400	
DOT GIS 6 Server (Travel Map)	$7,200	
DOT GIS WEB 2 Server (Travel Map)	$9,600	
Workstation PC	$1,560	Utility bills and average yearly repair/replacement costs for workstation equipment
Radio Console License	$1,000	License for radio use
Phone and Line	$384	Utility bills for desktop phones
Display Wall Monitors	$3,600	Utility bills and average yearly repair/replacement costs for display walls

Table 3: TOC Labor Categories

Labor Category	*Typical Job Responsibilities*	*Annual Costs (Outsourced)*	*Annual Costs (Self-Performed)*
TOC Operator	• Operate the TOC ATMS • Support public safety and incident management activities • Coordinate SDDOT response on roadway issues • Dispatch maintenance crews for snow and ice operations • Keep records of incidents roadway issues calls coming into the TOC	High – $99,281 Low – $83,396	High – $74,965 Low -$62,971
TOC Supervisor	• Act as manager on duty in the absence of the Operations Manager • Assist in developing protocols standard operating procedures • Ensure compliance with accepted guidelines and practices • Oversee the TOC operations floor • Provide QA/QC for all operational steps • Ensure policy and procedures are followed	High – $119,137 Low – $99,281	High – $89,958 Low – $74,965
TOC Operations Manager	• Manage all operational aspects of the TOC • Facilitate collaboration with internal and external stakeholders • Oversees and is responsible for day-to-day operations	High – $158,849 Low – $138,993	High – $119,944 Low – $104,951

5.2.2 Planning and Preparation Considerations

Planning and preparation considerations that may need to be addressed before the SDDOT TOC is developed and implemented follow.

5.2.2.1 Incremental Advancement of Functions and Support Technologies

The alternatives developed as part of this effort are structured to allow for incremental development of the SDDOT TOC in terms of organization, functionality, coverage area, and technological maturity.

- Organization – Effective outreach and collaboration with statewide stakeholders, including transportation agencies, public safety agencies, and others, can help the SDDOT TOC evolve organizationally to better address transportation safety, mobility, and reliability across the state.
- Functionality – Additional functionality of the SDDOT can be added over time as illustrated in the emerging need for data analytics capabilities. While SDDOT has traditionally captured a range of operational data, to date they have not leveraged the full benefits of having this data. As the data analytic capabilities mature and are integrated into the SDDOT TOC, archived data can enable a range of TOC-related functions such as optimizing staffing levels and defining and enhancing operational strategies.
- Coverage Area – As additional field equipment is developed and deployed across the state it can be integrated into the SDDOT TOC. A common example of this type of growth occurs when

state and local agencies deploy additional CCTV cameras, DMS, RWIS, and ESS. These new devices can be integrated and operated with legacy field devices.

5.2.2.2 Facility Considerations

The desired SDDOT TOC functions can be fully accommodated by using existing office space in lieu of constructing and maintaining a new facility, which could be cost prohibitive to SDDOT.

During the initial phases of assessing the feasibility of the TOC, workshops were held in Rapid City, Sioux Falls, and Pierre. Workshop attendees expressed a preference for a physical TOC in Sioux Falls due to the larger population from which to draw qualified job applicants. Stakeholders identified the Sioux Falls Public Safety Campus and the Utility Billing Building as potential locations with capacity to accommodate the TOC.

As specific functions and requirements are refined, further analysis will be needed to determine whether both facilities are viable, and which one is optimal. Both likely represent the more economical solutions for a physical, centralized location than creating, acquiring, or leasing another building.

5.2.2.3 Staffing Approach – Outsourced, Self-Performed or Hybrid

One of the key considerations when planning the development and deployment of the SDDOT TOC is determining whether to have operations completely outsourced to a qualified contractor to provide all operations staff, have SDDOT staff self-perform all functions, or employ a hybrid approach where contractor staff augment SDDOT staff. These operational approaches are defined in greater detail below.

- Outsourced – All TOC operational services are performed by contract staff. This approach has been adopted by many state DOTs nationally. The Iowa Statewide TMC is an example of where all operational services are provided by a contractor.
- Self-Performed – State employees perform all TOC operational services. For example, the Wyoming DOT indicated that they staff their TMC with 27 full-time employees and up to 10 additional seasonal employees. Similarly, the Maryland State Highway Administration (MDSHA) uses state employees to support operations at their four operation centers statewide. Attracting, hiring, training, and retaining employees, particularly seasonal employees, is often a challenge.
- Hybrid – TOC operational services are provided collaboratively between the agency and a contractor. Many times, off-hour services (overnights and weekends) are outsourced, while the DOT is responsible for operations during normal business hours. Tennessee DOT is considering such an approach for TMC operations statewide.

Benefits typically attributed to outsourcing TOC operations include:

- Cost Efficiency – There may be a greater motivation to drive cost efficiency, and efficient operational practices compared to that of a state or local DOT.
- Innovation and Expertise – Contractors' domain expertise and empirical knowledge of TOC operations can be of significant value to the DOT. They are also often positioned to capitalize on industry advancements more efficiently than are state and local DOTs.
- Quality and Accountability – Clearly defined quality requirements, performance requirements and competition among contractors can increase the quality of services in the TOC.
- Flexibility – Contractors can more quickly scale up or scale down operations through the movement of staff.

Challenges typically attributed to outsourcing TOC operations are:

- Lack of Flexibility – Contracts can be written too rigidly to accommodate changes in TOC as it evolves in terms of operational conditions, technological advancements, and operational strategies.
- Erosion of Loyalty – Existing DOT employees may aspire to work in the TOC and see it as an opportunity to advance their careers but would be unable to because staff is outsourced.
- Staffing – If cost is a significant factor in selecting a TOC operations contractor, unreasonably low bids may be submitted just to be selected to do the work. The contractor may then face significant challenges attracting qualified staff – especially in tough labor markets.
- Hidden Costs – The DOT must meticulously define the scope of work to be performed by the contractor. If items are missed in the scoping process the contractor may require change orders that escalate overall costs.

5.2.2.4 Stakeholder Engagement

As currently envisioned, the SDDOT TOC will serve as a focal point of surface transportation operations in the State. A key benefit of any TOC is the ability to foster collaboration among stakeholders, which in turn helps the center meet stakeholders' operational needs. Stakeholders may include:

- local transportation agencies
- SDDOT areas and regions
- state and local law enforcement
- fire
- emergency medical service (EMS) providers
- state and local emergency managers

Development and deployment of the SDDOT TOC must involve a concerted effort to engage stakeholders in two-way sharing of information. Engagement will help stakeholders understand what the SDDOT TOC does and how it may assist them with their operations and maximize the benefits to be derived from the center. Examples exist nationally where regional transportation operations stakeholders were unaware of what the operations center did or that it even existed. Engagement of stakeholders can take many forms, including:

- comprehensive tours of the SDDOT TOC
- presentations to stakeholders on the functionality of the center
- promotional materials

5.2.2.5 Operational Support Documentation

A range of support documentation is necessary to guide operation of the SDDOT TOC. Documents will need to be developed during the planning process to launch TOC operations and minimally will include:

- Standard Operating Procedures – Serve as step-by-step guides for TOC employees to carry out their routine operations. SOPs are unique to each operations center, but typically address:
    - call logging procedures
    - ATMS use
    - road closure reporting
    - incident reporting
    - DMS use
    - CCTV use

    - stakeholder communications
    - work zone notifications
    - Amber and Silver Alerts
    - 511 system use
    - bus crashes and incidents
    - railroad incidents

- Inter-departmental call-out procedures
- Staffing Plan – Governs staffing and scheduling management practices for employees working in the TOC. The staffing management plan is a living document that details activities being initiated to support staffing, scheduling, and training needs of the TOC.
- Training Plan – Outlines the training objectives, methodologies, approaches, components, timelines, and resources required to achieve specific learning goals for each position within the SDDOT TOC. The plan should address the required initial, recurring, and supplemental training regardless of whether the center is operated by State employees or outsourced labor
- Performance Measurement Plan – Describes the methodology for measuring and improving TOC performance
- Data Management Plan – Details how SDDOT will collect, process, analyze, secure, share, and archive data

The initial costs of developing supporting documentation are estimated in Table 4. Subsequent updates will be handled by an employee working in the TOC.

Table 4: TOC Planning and Preparation Costs

Item	***Estimated Cost***
Stakeholder Engagement	$46,750
SOPs	$35,000
Staffing Plan	$16,250
Training Plan	$16,250
Training Materials	$28,000
Performance Management Plan	$16,250
Data Management Plan	$16,250
Total	***$174,750***

5.3 Detailed TOC Alternative Descriptions

Detailed descriptions of each of the SDDOT TOC development and operational alternatives are provided below.

5.3.1 Alternative A – Maintain Existing Operations (Do Nothing Approach)

This baseline approach maintains SDDOT's operations as they are conducted today. Staff within the department's central, region, and area offices continue to conduct activities in an inconsistent, ad-hoc fashion. Coverage only includes single shifts during normal working hours, occasionally extending beyond these hours when needed. The approach continues to operate existing ITS technologies but does not expand them to include new functions such as variable speed limits or other active traffic management strategies. Because this approach maintains existing operations, capability to expand operations to include new staff or functions is limited. This adds greater operational pressures as traffic volumes and customer expectations grow in the future.

5.3.2 Alternative B – Remote and Focused

5.3.2.1 Functionality

TOC functionality provided by Alternative B includes:

- road weather management
- special event management
- traffic management
- traveler information
- public safety and incident management

5.3.2.2 Facility

Alternative B requires no new facilities. Operations staff have remote access to the ATMS platform. SDDOT, however, continues to occupy temporary physical space during the Sturgis Motorcycle Rally.

5.3.2.3 Workforce

To support the TOC functions provided with Alternative B, one full-time staff member is required, as well as two flex staff members for special and winter weather events working an estimated quarter-time.

5.3.2.4 Coverage Area and Hours of Operation

The hours of operation for Alternative B are normal business hours (approximately 7:00 AM to 5:00 PM) focused statewide on Interstate highways and four-lane expressways.

5.3.2.5 Estimated Costs

Table 5 lists summary cost estimates for Alternative B.

Table 5: Alternative B – Total Costs

Item	***Cost***
Capital Costs	$735,500
Operating and Maintenance Costs	$399,976
Staffing	High – $208,490 Low – $136,437
Planning and Preparation	$174,750
Total	***High – $1,518,716*** ***Low – $1,446,663***

Figure 29 summarizes Alternative B – Remote and Focused.

Figure 29: Alternative B – Remote and Focused

5.3.3 Alternative C – Distributed and Focused

5.3.3.1 Functionality

TOC functionality provided by Alternative C includes:

- road weather management
- special event management
- traffic management
- traveler information
- public safety incident management
- commercial vehicle operations and
- maintenance and construction information management
- data management

5.3.3.2 Facility

In Alternative C, SDDOT TOC functions are performed at desktop facilities in key locations (e.g., Sioux Falls, Pierre, and Rapid City). Virtual access to the ATMS platform is provided to each SDDOT Region. SDDOT continues to occupy temporary physical space during the Sturgis Motorcycle Rally.

5.3.3.3 Workforce

To support the SDDOT TOC functions provided with Alternative C, one full-time staff member is required, as well as three quarter-time flex staff members for special and winter weather events.

5.3.3.4 Coverage Area and Hours of Operation

The hours of operation for Alternative C are normal business hours (approximately 7:00 AM to 5:00 PM) focused statewide on Interstate highways and four-lane expressways.

5.3.3.5 Cost

Table 6 lists summary cost estimates for Alternative C.

Table 6: Alternative C – Total Costs

Item	*Cost*
Capital Costs	$1,341,000
Operating and Maintenance Costs	$414,720
Staffing	High – $332,591 Low – $215,151
Planning and Preparation	$174,750
Total	***High – $2,263,061*** ***Low – $2,145,621***

Figure 30 summarizes Alternative C – Distributed and Focused.

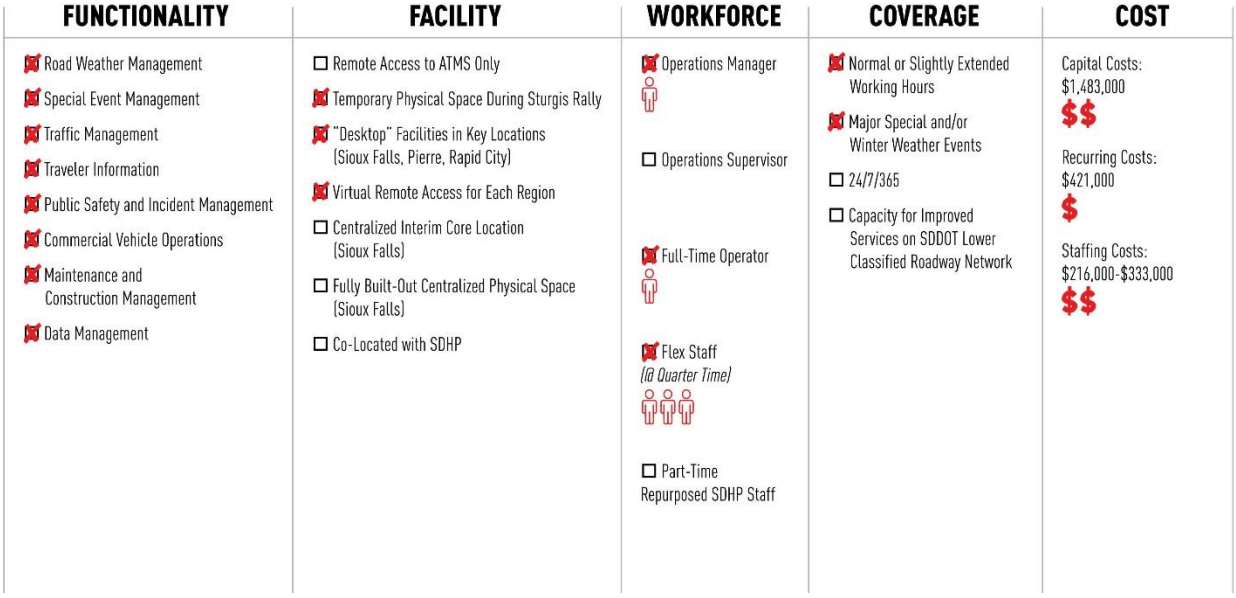


Figure 30: Alternative C – Distributed and Focused

5.3.4 Alternative D – Hybrid 24/7

5.3.4.1 Functionality

TOC functionality provided by Alternative D includes:

- road weather management
- special event management
- traffic management
- traveler information
- public safety incident management
- commercial vehicle operations and
- maintenance and construction information management
- data management

5.3.4.2 Facility

In Alternative D, SDDOT TOC functions are performed at desktop facilities in key locations (e.g., Sioux Falls, Pierre, and Rapid City). Virtual access to the ATMS platform is provided to each SDDOT Region. SDDOT will occupy temporary physical space during the Sturgis Motorcycle Rally.

5.3.4.3 Workforce

To support the SDDOT TOC functions provided with Alternative D, three full-time staff members are required, as well as three quarter-time flex staff members for special and winter weather events.

5.3.4.4 Coverage

The hours of operation for Alternative D are 24/7 with additional support during major incidents, weather, and special events. The coverage area is statewide on Interstate highways and four-lane expressways.

5.3.4.5 Cost

Table 7 lists summary cost estimates for Alternative D.

Table 7: Alternative D Total Costs

Item	*Cost*
Capital Costs	$1,482,00
Operating and Maintenance Costs	$422,608
Staffing	High – $531,150 Low – $341,093
Planning and Preparation	$174,750
Total	***High – $2,610,508*** ***Low – $2,420,451***

Figure 31 provides an overview of Alternative D – Hybrid 24/7.

Figure 31: Alternative D – Hybrid 24/7

5.3.5 Alternative E – Centralized 24/7

5.3.5.1 Functionality

TOC functionality provided by Alternative E – Centralized 24/7 includes:

- road weather management
- special event management
- traffic management
- traveler information
- public safety incident management
- commercial vehicle operations
- maintenance and construction information management
- data management

5.3.5.2 Facility

In Alternative E, SDDOT TOC functions are performed at a fully centralized facility in Sioux Falls. Virtual access to the ATMS platform is provided to each SDDOT Region. The Sioux Falls facility can be used as the hub during the Sturgis Motorcycle Rally, or SDDOT and SDHP can continue using temporary physical space.

5.3.5.3 Workforce

To support the TOC functions provided in Alternative E, one TOC Operations Manager, one TOC supervisor, and six full-time TOC operators are required, as well as three quarter-time flex staff members for special and winter weather events.

5.3.5.4 Coverage

Hours of operation for Alternative E are 24/7 with additional support during major incidents, weather, and/or special events. The coverage area is all SDDOT roadways, allowing improved services on principal arterial and secondary roads.

5.3.5.5 Cost

Table 8 lists summary cost estimates for Alternative E.

Table 8: Alternative E – Total Costs

Item	***Cost***
Capital Costs	$2,099,000
Operating and Maintenance Costs	$434,784
Staffing	High – $948,132 Low – $604,964
Planning and Preparation	$174,750
Total	***High – $3,692,666*** ***Low – $3,313,498***

Figure 32 provides an overview of Alternative E – Centralized 24/7.

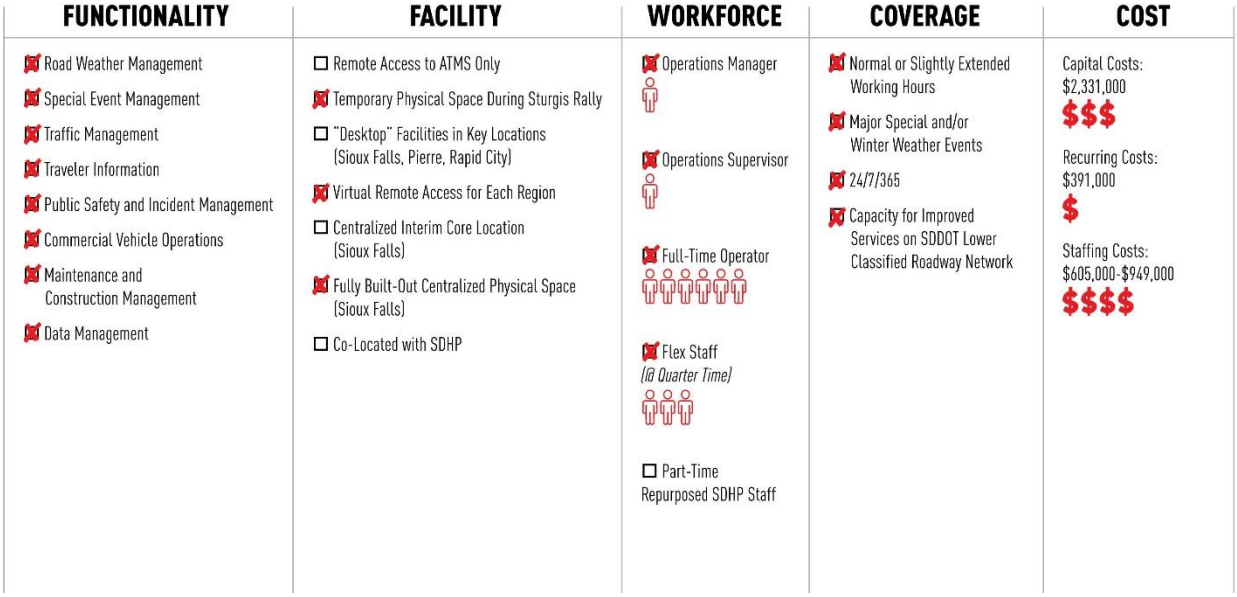


Figure 32: Alternative E – Centralized 24/7

5.3.6 Alternative F – Co-Located 24/7

5.3.6.1 Functionality

TOC functionality provided by Alternative F – Co-Located 24/7 includes:

- road weather management
- special event management
- traffic management
- traveler information
- public safety incident management
- commercial vehicle operations
- maintenance and construction information management
- data management

5.3.6.2 Facility

In Alternative F, SDDOT TOC functions are performed at a fully centralized facility in Sioux Falls. Virtual access to the ATMS platform is provided to each SDDOT Region. The Sioux Falls facility can be used as the hub during the Sturgis Motorcycle Rally, or the SDDOT and SDHP can continue using temporary physical space.

5.3.6.3 Workforce

To support the TOC functions provided with Alternative F, one TOC Operations Manager, two TOC supervisors, and five full-time TOC operators are required, as well as three quarter-time flex staff members for special and winter weather events. Operations are also supported by two part-time SDHP staff with primary responsibilities outside of the TOC but who are trained to supplement TOC staff during periods of high need. SDHP staff members are not included in the staffing cost estimates.

5.3.6.4 Coverage

Hours of operation for Alternative F are 24/7 with additional support during major incidents, weather, and special events. The coverage area is all SDDOT roadways, allowing for improved services on principal arterial and secondary roads.

5.3.6.5 Cost

Table 9 lists summary cost estimates for Alternative F.

Table 9: Alternative F – Total Costs

Item	*Cost*
Capital Costs	$2,402,000
Operating and Maintenance Costs	$442,672
Staffing	High – $967,989 Low – $616,959
Planning and Preparation	$174,750
Total	***High – $3,987,411*** ***Low – $3,636,381***

Figure 33 provides an overview of Alternative F – Centralized 24/7.

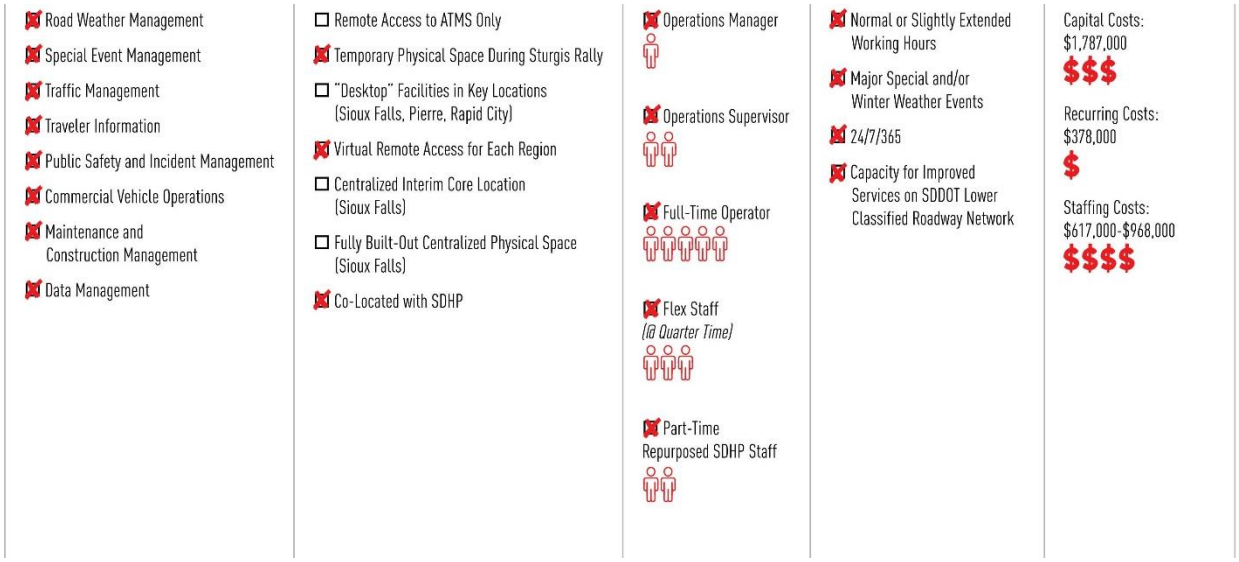


Figure 33: Alternative F – Co-Located 24/7

5.4 Summary

Table 10 summarizes the functionality, facility, work force, coverage area, hour of operation, and cost for each of the six alternatives A – F.

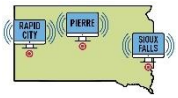
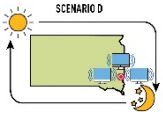
Table 11 scores each alternative in terms of functionality, collaboration, coverage, and cost.

Table 10: Summary of Alternatives

Alternative	*Functionality*	*Facility*	*Work Force*	*Coverage Area and Hours of Operation*	*Total Cost*
A *Maintain Existing Operations*	• Operate existing ITS technologies but no expansion	• No facility requirements	• No additional staffing requirements	• Normal business hours	No additional costs
B *Remote and Focused*	• Road Weather Management • Special Event Management • Traffic Management • Traveler Information • Public Safety Incident Management	• No facility requirements on an ongoing basis • Remote access to ATMS • Temporary physical space for Sturgis Motorcycle Rally	• TOC Operations Manager • 2 Flex Staff	• Normal business hours • Major Special and Winter Weather Events • Statewide on Interstate highways and four-lane expressways.	High $1,518,716 Low $1,446,663
C *Distributed and Focused*	• Road Weather Management • Special Event Management • Traffic Management • Traveler Information • Public Safety Incident Management • Commercial Vehicle Operations • Maintenance & Construction Management • Data Management	• Temporary Physical Space for Sturgis Motorcycle Rally • “Desktop” Facilities in Key Locations • Virtual Remote Access for Each Region	• TOC Operations Manager • 1 TOC Operator • 3 Flex Staff	• Normal business hours • Major Special and Winter Weather Events • Statewide on Interstate highways and four-lane expressways.	High $2,263,061 Low $2,145,621
D *Hybrid 24/7*	• Road Weather Management • Special Event Management • Traffic Management • Traveler Information • Public Safety Incident Management • Commercial Vehicle Operations • Maintenance and Construction Information Management • Data Management	• Temporary Physical Space for Sturgis Motorcycle Rally • “Desktop” Facilities in Key Locations • Virtual Remote Access for Each Region	• TOC Operations Manager • 3 TOC Operators • 3 Flex Staff	• Normal business hours • Major Special and Winter Weather Events • 24/7/365 • Statewide on Interstate highways and four-lane expressways	High $2,610,508 Low $2,420,451

Alternative	*Functionality*	*Facility*	*Work Force*	*Coverage Area and Hours of Operation*	*Total Cost*
E *Centralized 24/7*	• Road Weather Management • Special Event Management • Traffic Management • Traveler Information • Public Safety Incident Management • Commercial Vehicle Operations • Maintenance and Construction Information Management • Data Management	• Temporary Physical Space for Sturgis Motorcycle Rally (Optional) • Virtual Remote Access for Each Region • Fully Built Centralized Physical Space	• TOC Operations Manager • 1 TOC Supervisor • 6 TOC Operators • 3 Flex Staff	• Normal business hours • Major Special and Winter Weather Events • 24/7/365 • Capacity for improved services on SDDOT lower classified roadway network • Statewide on Interstate highways and four-lane expressways.	High $3,692,666 Low $3,313,498
F *Co-located 24/7*	• Road Weather Management • Special Event Management • Traffic Management • Traveler Information • Public Safety Incident Management • Commercial Vehicle Operations • Maintenance and Construction Information Management • Data Management	• Temporary Physical Space for Sturgis Motorcycle Rally (Optional) • Virtual Remote Access for Each Region • Fully Built Centralized Physical Space	• TOC Operations Manager • 2 TOC Supervisors • 5 TOC Operators • 3 Flex Staff	• Normal business hours • Major Special and Winter Weather Events • 24/7/365 • Capacity for improved services on SDDOT lower classified roadway network • Statewide on Interstate highways and four-lane expressways.	High $3,987,411 Low $3,636,381

Table 11: Summary Scoring Table

Alternative	*Functionality*	*Collaboration*	*Coverage*	*Cost*
A – Existing 	**1**	**1**	**1**	**5**
B – Remote and Focused 	**3**	**1**	**2**	**4**
C – Distributed and Focused 	**5**	**2**	**2**	**3**
D – Hybrid 24/7 	**5**	**3**	**4**	**2**
E – Centralized 24/7 	**5**	**4**	**5**	**1**
F – Co-Located 24/7 	**5**	**5**	**5**	**1**

1 = Lowest Score, 5 = Highest Score

6.0 FINDINGS AND CONCLUSIONS

6.1 Findings

6.1.1 Introduction

South Dakota faces unique transportation challenges due to its rural makeup, severe winter weather, and significant events like the Sturgis Motorcycle Rally. The SDDOT has deployed ITS devices to address these issues but requires a centralized TOC to manage them and enhance their functionality.

6.1.2 Literature Review

A review of national literature and peer exchanges with neighboring states revealed common TOC functions, including traffic management, traveler information, road weather management, maintenance and construction information management, special event management, public safety incident management, commercial vehicle operations, and data management. TOCs were overall found to be a necessary tool for DOTs to manage their transportation network effectively.

6.1.3 Operational Concepts

Current SDDOT practices involve individually managed ITS devices that can cause strain on SDDOT resources and staff. A statewide TOC would unify control over these systems, improving traffic management and incident response. Operational concepts were explored through examples demonstrating the potential benefits of a TOC, such as enhanced communication and quicker response.

6.1.4 Alternatives Analysis

Five TOC models were analyzed against a no-build alternative. Models ranged from a remote, low-cost option with limited functions to a centralized, co-located facility with 24/7 operations. The models' functionality, staffing needs, and costs were compared, with more complex models offering greater benefits but higher costs.

6.1.5 Conclusion

The South Dakota Department of Transportation has been working toward the creation of a Traffic Operations Center for many years. To identify and help overcome the roadblocks, the project team conducted a TOC feasibility study, which reviewed literature, developed operational concepts, analyzed alternatives, and presented findings and recommendations.

Based on the findings of the literature review and the analysis of operational and safety data during the alternatives analysis, it is recommended that the SDDOT pursue further steps toward deploying a statewide TOC.

While creating and maintaining a TOC is not without challenges, the peer agencies interviewed reported numerous successes proving the value of a TOC, regardless of the model. The Iowa DOT reported an average reduction of 10 minutes of response time with the use of their TMC when coupled with advanced data analysis tools that utilize third party data from Bluetooth devices, synthesized with machine learning and custom algorithms, to identify noteworthy traffic disturbances. The Wyoming DOT estimated a 50% reduction in clearance times on critical corridors after opening their facility and expanding their field device coverage. The North Dakota DOT estimated their TMC would generate a benefit/cost ratio of greater than seven.

Within South Dakota, a TOC has already yielded considerable benefits when deployed during the Sturgis Motorcycle rally. Initial analysis of Statewide and year-round TOC operations yields promising benefits with more than 77% of the delays on the Interstate and statewide principal arterial system caused by unplanned events. With costs of freight rising more quickly than inflation, improving the reliability of travel and reducing the 1.5 million truck delay hours within the state will demonstrate the economic benefits a TOC can offer.

As a rural state, response times to incidents averaged over 100 minutes between 2020 and 2022. With the risk of secondary crashes and serious injury or fatalities increasing during the wait for a response, having a TOC will go a long way toward improving safety overall and achieving SDDOT's goal of zero fatalities. This is especially noteworthy considering that 39% of the statewide crashes are caused during inclement weather, 8% are within work zones, and 5% are secondary crashes.

The implementation of a TOC is expected to improve safety, efficiency, and response time for traffic incidents and other transportation-related events. Specific recommendations for the TOC and next steps are included in the following section.

7.0 RECOMMENDATIONS

7.1 Recommendation I: Advanced TOC Deployment through Phased Implementation

Each of the TOC alternatives described in the alternatives analysis can be deployed singly, limited to the selected TOC approach. However, two or more of the TOC alternatives can also be deployed in phases, changing with the evolving resources, budget, and needs of the SDDOT.

Phased approaches to TOC implementation are common across other states researched during the literature review. Even if phased implementation was not part of the first deployment, all of the TOCs or TMCs experienced changes to their models over time.

For South Dakota, phased implementation may resemble one of the pathways shown in Figure 34.

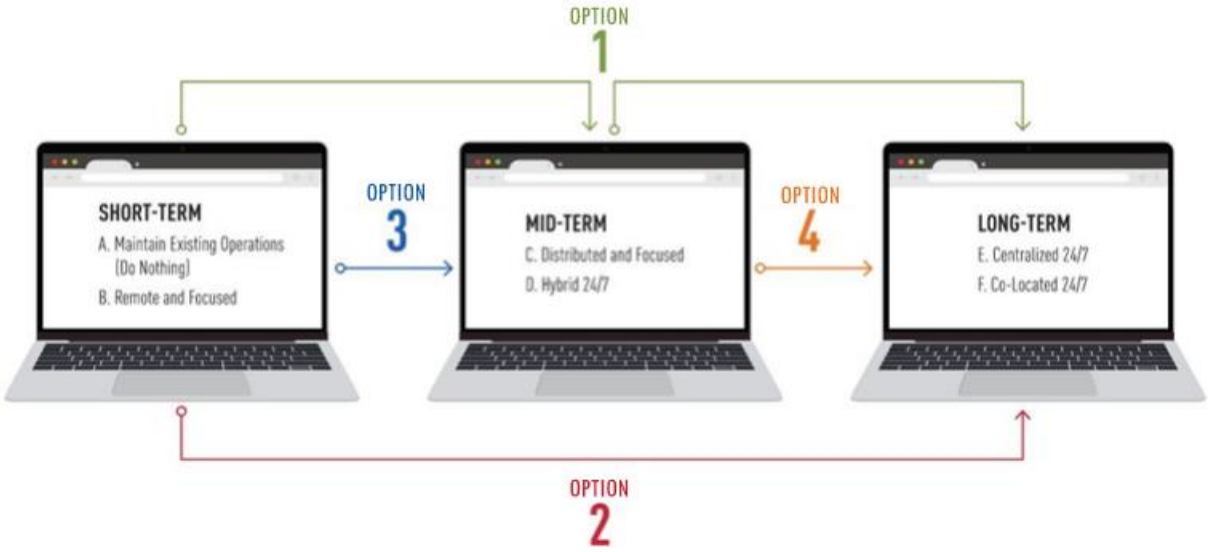


Figure 34: TOC Model Phasing

While the phasing options vary slightly, the concept for each comes from the same idea. The first TOC deployment will be relatively simple but will increase in complexity and benefits over time. Taking this phased approach helps balance the need for a TOC with the large amount of funding, staff, and effort needed to create one.

Cost and workforce shortages were common concerns about the feasibility of the DOT. While the benefits of Alternative E and F are impressive, they require twice as much budget and 3 to 4 times the staff as the Remote & Focused approach. Pursuing a large, continuously staffed center and its many benefits is exciting, but hurdles to implementation could stop the project before any of its benefits are realized. Furthermore, if the full-scale vision takes years to achieve, that means that some benefits, in the form of crashes prevented, lives saved, and delays minimized will be missed.

It may be difficult to acquire funding or support for the grandest TOCs without phasing the project. Smaller deployments can serve as a proof-of-concept for decision-makers and showcase the benefits of future expansion. A TOC staffed only during business hours can show the impact on response times, justifying an expansion of operating hours. While the positive benefits of TOCs and TMCs nationwide have been well documented, the type and scale of benefits differ in different circumstances. Having a proven, documented practice is more persuasive than other states' findings alone and can help guide growth areas and next steps. This results in a TOC more tailored to the state's needs.

Even the simplest TOC model will require changes to existing systems. In addition to the changes inherent to the TOC, parties interacting with the TOC will have to adapt too. SDDOT staff in other departments or members of outside agencies, such as the SDHP, will have to learn how to interact with the new TOC. Responsibilities and technology are likely to shift. Starting from a simpler deployment will make that transition more manageable, providing an opportunity to learn and adjust to the TOC as it grows.

During revisions of the final report, the South Dakota Department of Transportation received notice that it was awarded grant funding to deploy a statewide ATMS. As outlined in the report, ATMS is crucial for many of the ITS solutions SDDOT would like to implement and will be a core component of any TOC model. This means that Alternative A (Do Nothing) has already been surpassed.

The ultimate goal should be for 24/7/365 monitoring, given that 73% of crashes occur outside normal business hours. However, for the best combination of benefits and an actionable timeline, it is recommended that the SDDOT begin the first phase with a TOC model like the Remote and Focused (Alternative B) or the Distributed and Focused (Alternative C) strategies. These models reduce costs and number of staff, so focus can be centered on establishing the basic framework of a TOC.

Centralizing existing traffic operations across the DOT and hiring qualified staff were both areas of concern for stakeholders. If the initial model does not perform all TOC functionalities, transitioning workload, redefining roles, and developing new procedures will be greatly reduced. A phased approach will create a template for how new responsibilities should be incorporated into the TOC as needs arise. Similarly, the smaller staff size means the DOT can focus on repurposing existing staff or making select strategic hires. A larger deployment poses the challenge of trying to find many qualified candidates at the same time and the risk of depriving other DOT offices of staff they need.

The following recommendations identify implementation strategies to transition SDDOT from current operations into the initial TOC deployment and through the final TOC vision.

- ***Recommendation II:*** To achieve the centralized TOC vision, a facility must be identified. Repurposing an existing facility can expedite the time it takes to achieve this vision precipitously. This recommendation identifies the next steps in the facility process.
- ***Recommendation III:*** Systems Engineering is a critical next step for initial and ultimate deployment. Implementing a TOC is expected to require the selection of new software, the creation of new job titles and roles at SDDOT, the acquisition or transfer of staff, and large-scale training efforts. This recommendation outlines this process, what resources to utilize, and where to start.
- ***Recommendation IV:*** Analyzing a facility and advancing systems engineering will both require additional effort. A common barrier to TOC implementation is a lack of funding. This recommendation outlines how SDDOT can leverage recent grant funding and other grant opportunities to expedite the planning, engineering, and deployment processes.

7.2 Recommendation II: Conduct Facility Assessment

When the need arises and resources are available for a physical location, two Sioux Falls locations emerged as candidates in this research. The Sioux Falls Public Safety Campus (PSC) is a state-of-the-art facility that was completed in late 2023. In addition to facilities to train emergency personnel, the space has offices for law enforcement, fire and rescue, and other emergency services. Proximity of TOC staff to emergency responders may help build relationships and understanding between agencies. This may prove helpful when the TOC is involved in emergencies.

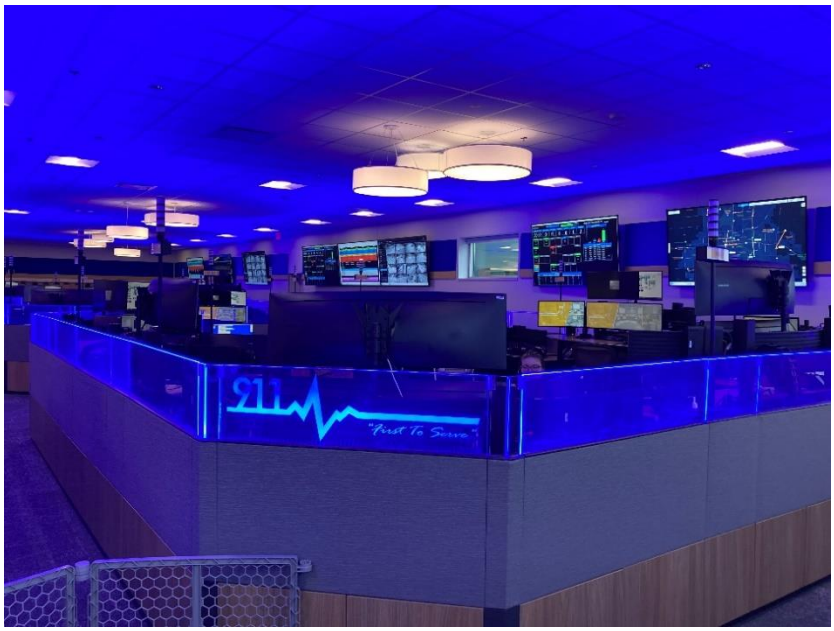


Figure 35: Public Safety Facility 911 Dispatch Center

Another potential location is the former Utility Billing Building, west of the Event Center. While the facility does not share space with any emergency services, retrofitting an existing government building would require significantly less budget and time than a new facility. Both the Utility Billing Building and PSC have space available for TOC staff and equipment.

At various stages of the project, the Sioux Falls Public Safety Campus (PSC) was discussed as an ideal location for a permanent TOC. The PSC opened in the fall of 2023 (Schwan 2023) and is used for a variety of public safety efforts. Law enforcement, fire and rescue, emergency management, and emergency communications all use the 42-acre space (City of Sioux Falls n.d.). A significant portion of this space is dedicated to infrastructure used to train responders, such as full-size buildings used to simulate emergencies, a shooting range, and a 13-acre track for emergency vehicles.

Most relevant to the TOC, a 40,000 square foot administrative building houses emergency dispatch, offices, classrooms, and amenities such as a recreation center and kitchen space. The dispatch call center occupies a significant amount of space in the building and has been discussed with the PSC as a space for TOC staff.

The call center is set up for 911 dispatchers, so many of the building components needed for a TOC have already been met. The facility has redundant power from both Xcel Energy and the City of Sioux Falls, plus full generator backup. Telecommunications infrastructure is fast and reliable to meet the standards of emergency responders. Dispatcher workstations are similar to TOC workstations, with multiple monitors at each station and large screens mounted on walls so staff can simultaneously monitor the same situation.

Co-locating the TOC with emergency services also brings opportunities for more coordination with partner agencies. The shared facility offers more opportunities for TOC staff to meet and interact with

staff outside of the DOT. The TOC can benefit from some of the pooled resources at the facility. Additionally, the amenities at the PSC may be useful in attracting candidates to jobs at the TOC.

To test the viability of this location for the TOC, further coordination is required from SDDOT, SDHP, and the Sioux Falls PSC. All parties must agree to TOC use of the space and terms of agreement must be thoroughly defined. The space should be assessed for both short-term and long-term use. The team should develop an understanding of future needs and growth for the TOC and PSC to determine the suitability of an enduring partnership. Lastly, the team should develop more precise cost estimates to compare to other TOC deployment options. The estimates should include costs of leasing the space, furniture, technology, and recurring fees such as utility bills.

7.3 Recommendation III: Continue Advancing Key Systems Engineering and Planning Deliverables to Ensure Successful Deployment

A key step toward an SDDOT TOC is a systems engineering analysis. As a large and complex project, the analysis will help break the TOC into smaller, focused components that can be engineered to meet specific needs and criteria. The FHWA requires a systems engineering analysis for ITS projects receiving federal funds.

The systems engineering process usually takes place after the general parameters of a project have been determined and the initiative can continue to narrow in focus. In this case, the project team would proceed with systems engineering after choosing a model like those described in the alternatives analysis portion of this report. Alternatively, the full-build (Alternative E or F – Centralized 24/7) can be targeted and systematically phased.

The FHWA provides a wealth of documentation to facilitate the systems engineering process on its website. The systems engineering process requires many stages and deliverables (Figure 36), but the next major milestones are the Concept of Operations and System Requirements.

The Concept of Operations describes at a high level how the new system will function from the perspective system users. Some of this deliverable will mirror content included in the Phase II of this report, as it will walk through common circumstances and functions of the TOC. However, the Concept of Operations should focus on a single alternative presented as part of the project and reflect that alternative alone.

System Requirements define the necessary components of a system. They build on previous system engineering steps, particularly the Concept of Operations. Stakeholders should be heavily involved in providing input for the system requirements. Requirements should be developed in consideration of laws and policies as well as existing ITS infrastructure and systems.

Other documents that would aid in the project's next steps include a Business Plan and an Operations Plan. A Business Plan would further document existing, planned, and proposed roles and technologies for the TOC, to help build a case for agencies and partners to "invest" needed resources. The Business Plan may be a valuable asset if this research study does not incite action from key decision-makers. An Operations Plan would describe how the TOC would operate, including staff roles, procedures, and financial needs. This would provide a realistic vision of the TOC and refine the planning process.

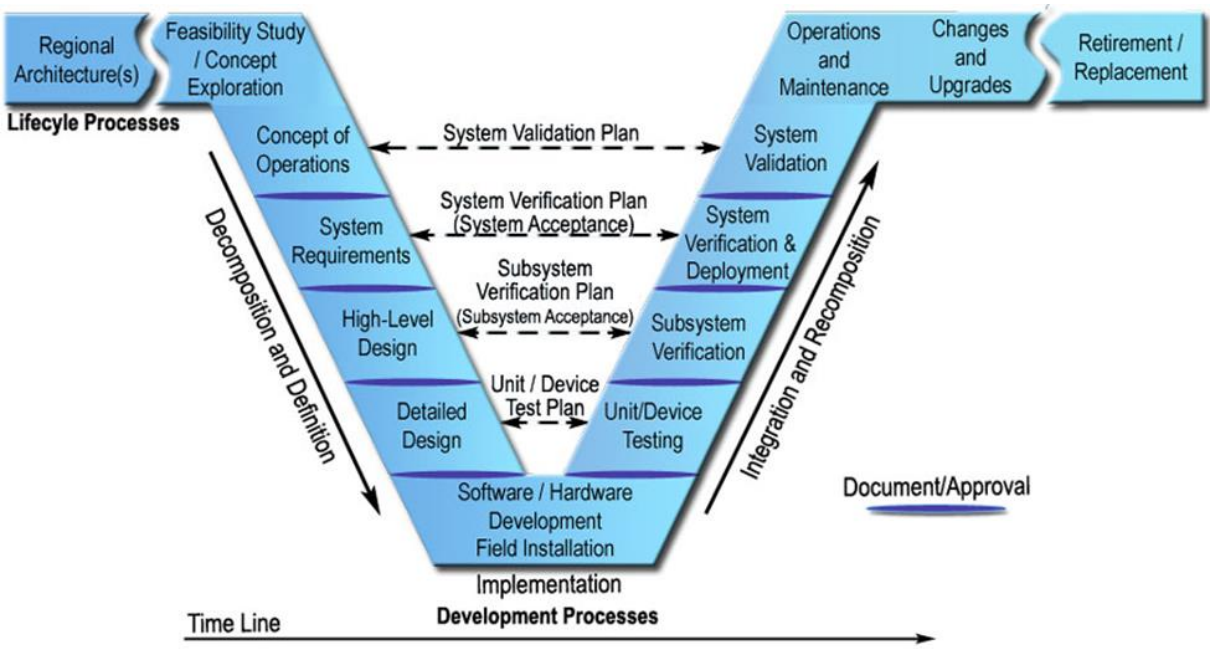


Figure 36: Systems Engineering V Diagram

The SDDOT may choose to add to or enhance the systems engineering process to suit its needs. However, for the overall success of the project and to improve chances of securing federal funds, it is recommended that the project create these documents and follow FHWA ITS System Engineering guidance at a minimum.

7.4 Recommendation IV: Pursue Competitive Grant Funding to Expedite Delivery and Reduce Financial Burden of Plan

The final recommendation of this report is to pursue grant funding for the TOC. Even the simplest TOC rollout will require significant capital. In the past, the projected cost of a TOC was one of the reasons the project did not move forward. Pursuing grants will allow SDDOT to move faster towards establishing a TOC. More options for TOC functions would also become available with higher levels of funding. The project team has estimated a total project need of $1.5 million to $4 million depending on the alternative chosen.

During revisions of the final report, the South Dakota Department of Transportation received notice that it was awarded grant funding to deploy ATMS through the Strengthening Mobility and Revolutionizing Transportation (SMART) Grants program. Winning a Phase I SMART Grant makes SDDOT eligible for a Phase II Implementation Grant, which can be up to $15M. Implementation grants are for technology deployments and will not fit with all elements of the TOC, but access to these funds accelerates the deployment of the TOC and makes the more advanced Alternatives more achievable.

In addition to a Phase II SMART Grant, the following grants have been identified as a good fit for SDDOT TOC funding:

- The Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Program provides funding to projects aimed at improving transportation's resiliency or operations during emergencies, evacuations, and severe weather.
- The Advanced Transportation Technologies and Innovation (ATTAIN) Program awards funding for projects that use advanced or emerging technology to improve transportation.

- The Infrastructure for Rebuilding American (INFRA) and Rural Surface Transportation Programs have funds typically used for highway projects, with emphasis on freight and rural areas, respectively.
- The Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Programs offers funding to many kinds of infrastructure projects and weighs safety, economic benefits, environmental benefits, and equity improvements heavily in their selection process.

Other funding sources that should be explored include the Highway Safety Improvement Program (HSIP), the Congestion Mitigation and Air Quality (CMAQ) Improvement Program, and Safe Systems for All (SS4A).

Most of these grant opportunities are competitive and evaluate applications on both the strength of the project and its benefits to specific goals of the federal government. When applying for funding, it is important to highlight benefits that align with these goals. Some common improvement targets and their relation to the project are:

- **Rural areas** – Several grant programs set funds aside for rural populations, and South Dakota is one of the most rural states in the country. Of the 66 counties within the state, 30 are classified as rural and 34 are classified as "frontier" – meaning there are fewer than 6 people per square mile (US Department of Health and Human Services 2021).
- **Equity** – Many grants ask that funds be used to help disadvantaged populations. These populations may be defined differently in different programs, but frequently aim to aid racial minorities, low-income populations, tribal communities, and other marginalized people. Marginalized communities are often disproportionately impacted by transportation related issues, such as traffic deaths, pollution impacts, and transportation costs and insecurity (US Department of Transportation 2023). Around half of South Dakota falls within census tracts defined as Disadvantaged by the Climate and Economic Justice Screening Tool (CEJST), areas of persistent poverty, or designated tribal lands (US Department of Transportation n.d.), as shown in Figure 37.
- **Climate and Environment** – Grants often require or encourage applicants to submit projects with significant environmental benefits. The proposed TOC and related technologies aim to decrease congestion and improve efficiency, leading to a reduction in fuel consumption and emissions. The proposed solutions do not require large construction projects or the production of large volumes of materials typical of conventional transportation solutions.
- **Safety** – The FHWA continues to prioritize safety for transportation with a vision of zero deaths, a goal shared by the SDDOT. The TOC aims to monitor and manage traffic through dangerous situations, such as after accidents or during severe weather. The reduction in detection and response times to incidents is a proven benefit of TOCs. The TOC will help decrease the number of crashes and their severity.

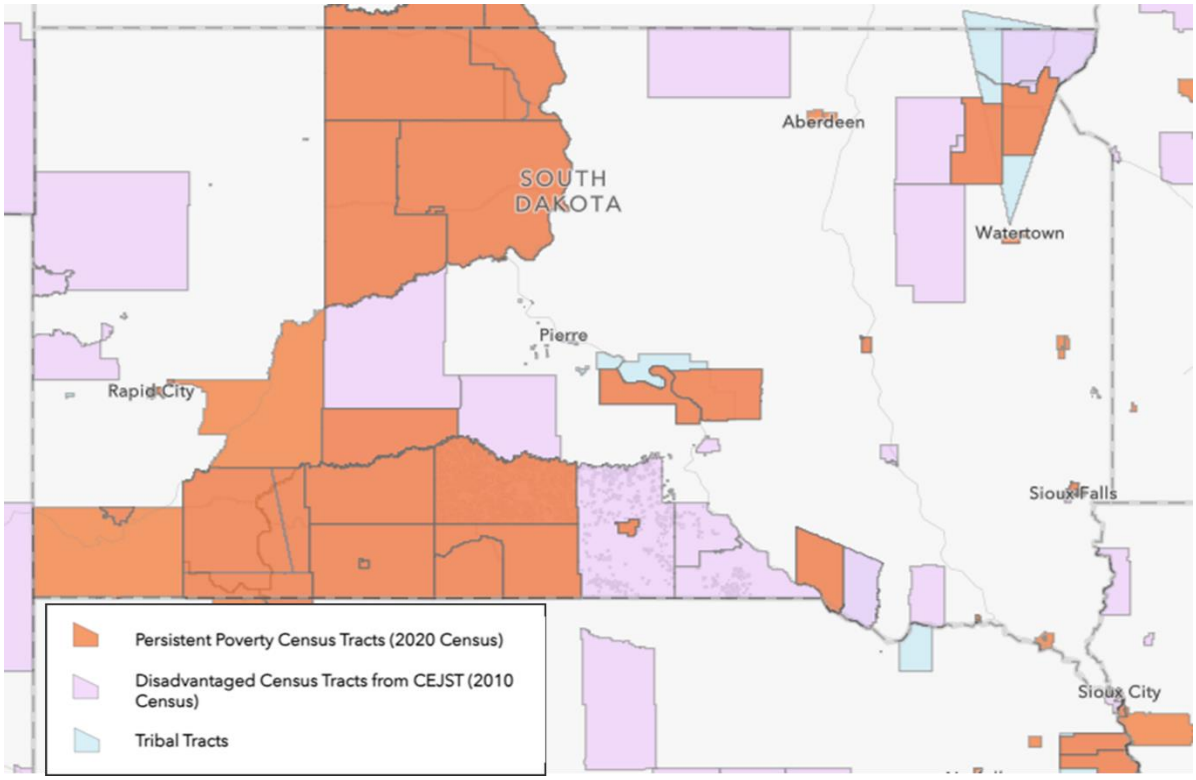


Figure 37: Persistent Poverty Census Tracts, Disadvantaged Census Tracts, and Tribal Lands in South Dakota

To continue progress toward a successful TOC, the project team recommends SDDOT take a phased approach toward deployment, starting with a smaller deployment and working toward a 24/7 facility with a physical location in Sioux Falls. Specifically, the project team recommends beginning with a fully remote model like the example described in Alternative B.

The ATMS deployment funded by the successful SMART Grant will require systems engineering work similar to what is needed for the TOC. For example, both projects will require detailing core traffic management and operations procedures. Where the projects overlap, the projects can work in tandem to share information and develop a more complete picture of the future of SDDOT.

In 2025 and 2026, SDDOT can focus on a foundational model of an ATMS and TOC, undergoing a systems engineering process and initial deployment. During this period or shortly after, the SDDOT can plan for future models by conducting a facility assessment. The TOC model can expand as new projects are deployed and more functionality is required. As the SDDOT grows more comfortable with the TOC, it can continue looking forward toward a model closer to Alternative E or F, aiming for a 2028-2030 timeframe.

Regardless of the determined model, the chosen approach should undergo further planning and the systems engineering process. As the desired permanent, physical location for the TOC, the Sioux Falls Public Safety Campus should be assessed for suitability. Stakeholders for the TOC and PSC should work together to ensure all needs are met. Finally, SDDOT should pursue grant funding for the project to achieve a faster and more advanced deployment.

8.0 RESEARCH BENEFITS

This research created a guide for the SDDOT on expected benefits, project costs, and potential challenges of a TOC. Findings on TOCs vary greatly depending on factors such as location, size, and technologies in use. The project used South Dakota-specific data and research to identify models, costs, and focus areas for the region. The recommendations of the report reflect a realistic, practical vision for a statewide TOC.

Centralized operation of a TOC would significantly enhance system performance by improving the reliability and efficiency of the transportation network, particularly during weather events, crashes, and special events. This improvement is crucial for freight vehicles, which constitute a significant portion of traffic and experience a substantial economic impact during delays.

TOCs have a proven track record of reducing incident identification and response times, which are vital in life-threatening situations. Enhanced coordination with emergency services can save lives and mitigate the impact of incidents. Environmental benefits include reduced emissions due to improved traffic management, which decreases congestion and idling times.

Effective communication and alerts are another key benefit, as TOCs can quickly update the public on traffic conditions, incidents, and road closures through various channels like DMS and the SD511 system. This also facilitates better coordination with partner agencies, enhancing overall response efforts. The TOC would enable strategic data collection and analysis, allowing for data-driven decisions and the development of effective traffic management strategies. Collaborations with universities could further enhance data analytics and the evaluation of new technologies. Utilizing advanced technologies like variable speed limits and queue warning systems would further improve traffic flow and safety.

The report suggests a phased implementation approach for the TOC, allowing for gradual improvements and scalability based on available resources and needs. This approach, combined with pursuing competitive grants, could reduce the financial burden and expedite the implementation of the TOC.

The report documents these benefits and takes an important step toward a statewide TOC and a long-term goal of the DOT.

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Appendix A: Traffic Operations Center Functions – Graphic Format

WHAT
TRAFFIC MANAGEMENT

Traffic Monitoring

SDDOT currently owns and operates cameras and vehicle detectors throughout the state but does not have dedicated staff available to monitor traffic. During certain times such as a winter storm or a significant crash, the DOT may choose to dedicate staff to monitoring devices to help identify and respond to incidents faster.

Planned Work: Variable Speed Limits

SDDOT is currently planning to deploy variable speed limit (VSL) systems along multiple Interstate corridors. These systems will temporarily lower speed limits during certain periods to improve safety. VSL systems require careful monitoring, to ensure that speed limit adjustments are timely in response to changes to roadway conditions.

Planned Work: Advanced Traffic Management System

SDDOT plans to procure an advanced traffic management system (ATMS) in 2025. ATMS will give the SDDOT the ability to control many ITS devices from a remote location, allowing staff to centralize existing traffic operations and perform more complex traffic management operations within the same software.

Future Opportunity: Wrong-Way Vehicle Detection

At locations with a history of wrong-way incidents, a detection and deterrence system can be implemented to help prevent crashes. Sensors on ramps detect vehicles traveling in the wrong direction and can trigger DMS or simply notify TOC staff. After verifying an incident via CCTV cameras, TOC staff can alert first responders and post messages on DMS warning traffic.

WHY

23% of congestion on South Dakota Interstates and Principal Arterials occur during recurring congestion events in Sioux Falls, Rapid City, Aberdeen, and Brookings, construction work zones or special events.

HOW

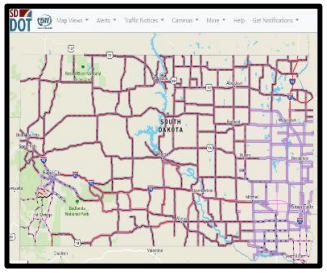
TRAFFIC MANAGEMENT

		NORMAL OPERATIONS	SEVERE WEATHER	TRAFFIC INCIDENT	SPECIAL EVENT	EQUIPMENT FAILURE
SCENARIO		A typical day during rush hour with no inclement weather, traffic incidents, or lane closures.	A winter storm with significant snowfall leads to road closures.	A wrong-way driver enters the freeway.	A SDSU football game draws high traffic volumes near campus.	A communications network failure impacts dozens of devices in the area.
EXISTING	SDDOT ITS	SDDOT remain ready to react to roadway incidents when they are notified of an event.	SDDOT staff monitor storm with CCTV cameras when staff is available. Field staff open and close road closure gates.	SDDOT staff likely have no idea that a wrong-way event has occurred until it is over.	SDDOT staff monitor area with CCTV cameras when staff is available, and post messages to DMS and 511 as needed.	SDDOT staff discover the outage when trying to operate the device, and work with field staff and/or BIT to determine the cause of the outage and get devices functioning again.
	SDDOT DIVISION OF OPERATIONS					
	SD HIGHWAY PATROL	SDHP monitors the roadways for moving violations and traffic incidents, notifying SDDOT as incidents arise.	SDHP responds to incidents as they occur.	SDHP deploy officers to stop driver and protect others on the roadway.	SDHP monitors traffic near event and directs traffic when signals become overwhelmed.	N/A
WITH TOC	TRAFFIC OPERATIONS CENTER	TOC monitors traffic for unplanned events or incidents and deploy traffic management strategies as needed.	TOC monitors conditions on CCTV cameras. TOC staff remotely control road closure gates. Staff use VSL to lower speed limits and monitor to return speed limits to normal later.	Detection systems alert TOC of a wrong-way driver. TOC staff monitor situation via CCTV cameras. TOC posts messages to DMS to warn drivers of a wrong-way vehicle in the area.	TOC monitors conditions on CCTV cameras. TOC monitor queue detection for traffic backing up on ramps and advise event traffic to use specific routes to the stadium.	TOC is notified of outages and given diagnostic information via ATMS. TOC staff work with contractors or maintenance staff to bring communications back online.

WHAT

TRAVELER INFORMATION

SDDOT is responsible for disseminating a wide range of information to the traveling public and operational partners. Effective traveler information systems, based on real-time data, help SDDOT effectively manage operations and implement actions to mitigate adverse impacts when events occur.

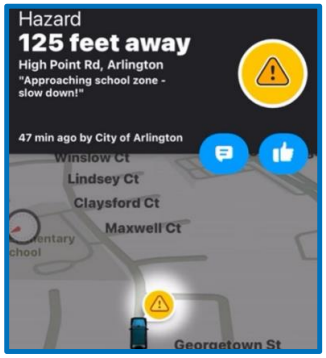


South Dakota 511

SDDOT operates a traveler information system to inform travelers of real-time travel conditions. Information on weather and road conditions, commercial vehicle restrictions, events, and incidents are available to the public via mobile phone application, website, kiosks at rest areas, or by calling 511. Users can also sign up for text or email alerts for specific information.

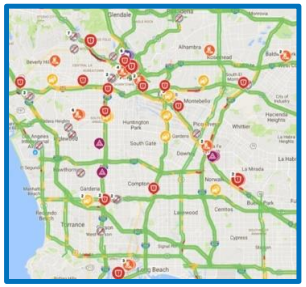
Dynamic Message Signs

SDDOT owns and operates fixed DMS as well as many portable DMS used to supplement fixed signs during temporary traffic events such as construction.



Future Opportunity: Location-Based Alerts

Both the public and private sectors have explored ways to communicate information to drivers based on GPS location using smartphones and in-vehicle displays. Alerts convey similar information that would be available in 511 or on DMS, but the alerts are only triggered when the driver is within a certain distance from the area of concern.

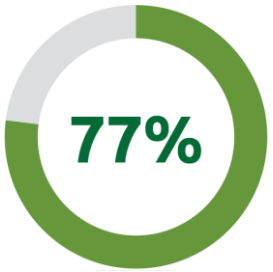


Future Opportunity: Crowdsourced Information

Another expansion of traveler information systems involves utilizing crowdsourced data. Companies like INRIX aggregate crowdsourced data and can produce maps and associated alerts for traffic incidents or congestion. The SDDOT can incorporate this data into their 511 system for dissemination.

WHY

77% of congestion on South Dakota Interstates and Principal Arterials occur during unplanned events related to weather, crashes, and roadway maintenance that would benefit from enhanced and expanded traveler information.



HOW

TRAVELER INFORMATION

		NORMAL OPERATIONS	SEVERE WEATHER	TRAFFIC INCIDENT	SPECIAL EVENT	EQUIPMENT FAILURE
SCENARIO		A typical day during rush hour with no inclement weather, traffic incidents, or lane closures.	A winter storm with limited visibility and slick roadway surfaces.	A car crash involving several vehicles closes a lane of traffic.	Lifelight, a music festival draws 25 thousand people to Sioux Falls.	A DMS stops functioning and cannot display messages.
EXISTING	SDDOT ITS SDDOT DIVISION OF OPERATIONS	SDDOT remain ready to react to roadway incidents when they are notified of an event.	SDDOT staff update DMS with severe weather warnings and advisories. ESS data is processed by the MDSS and pushed to 511.	SDDOT staff update DMS upstream with lane closure and crash information. If the incident is expected to take several hours to clear, it may be added to SD 511.	SDDOT staff update DMS to direct traffic. Events can be added to SD 511.	SDDOT staff may not notice the failure until they attempt to use the sign. Staff can use SD 511 and nearby DMS to convey messages. Operations staff will work with field staff to deploy portable DMS if needed.
	SD HIGHWAY PATROL	SDHP monitors the roadways for moving violations and traffic incidents, notifying SDDOT as incidents arise.	SDHP coordinates with SDDOT to update winter storm messages in 511 and on DMS.	SDHP coordinates with SDDOT to update incident messages in 511 and on DMS.	SDHP coordinates with SDDOT to update event messages in 511 and on DMS.	N/A
WITH TOC	TRAFFIC OPERATIONS CENTER	TOC monitors traffic conditions via cameras, field sensors, and conversations with field staff and posts messages to DMS and 511 as congestion occurs.	TOC monitors weather via ESS, cameras, and conversations with field staff, inputting additional weather information into 511 and updating DMS messages as conditions change. Location-based alerts are sent to those in the storm and near winter operations vehicles.	TOC verifies and monitor incidents with cameras and field sensor data. TOC coordinates an appropriate response based on severity of the incident with emergency dispatch, tow trucks, and maintenance. TOC inputs incidents into 511 and updates DMS and location-specific alerts.	TOC schedules special event messages, such as suggested event traffic routing, to be posted via DMS, 511, and location-specific alerts. During the event, TOC monitors traffic in the area and updates messages as needed. TOC may coordinate with police if special traffic direction is needed.	TOC receives an alert about the equipment failure and coordinate maintenance with SDDOT ITS, resulting in reduced downtime.

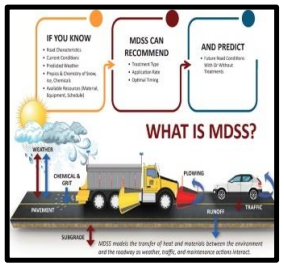
WHAT

ROAD WEATHER MANAGEMENT

Weather plays a large impact on the safety and reliability of transportation. Many resources are devoted to keeping roadway surfaces clear and safe for travel. Traffic operations must combat the risks posed by limited visibility and slick roadways.

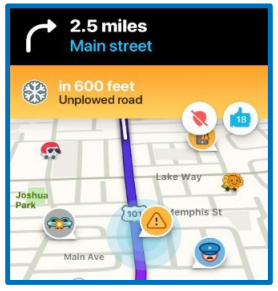
Winter Maintenance

To address winter weather effectively and efficiently, SDDOT uses a variety of technologies to gather data, inform travelers, and manage equipment. Normal winter maintenance operations occur during a storm but may be extended if highway/traffic conditions warrant and if staff is available.



Maintenance Decision & Support Systems

MDSS pulls and analyzes weather and road condition data from ESS, in-vehicle plow equipment, and feedback from operations staff. MDSS provides recommendations on material to use, the application rate, and when application should occur. The system also tracks maintenance activities throughout a winter storm.



Future Opportunity: Spot Weather Warnings

Using devices on winter maintenance vehicles, alerts can be sent to motorists when they are within a certain proximity of the vehicle. Drivers would be notified through their phone or on the dashboard of a connected vehicle. The warning would advise drivers to use caution when near the maintenance vehicle and could also include important weather information pulled from SDDOT's MDSS or RWIS.

Environmental Sensor Stations

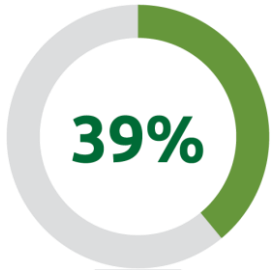
The DOT maintains ESS, which compile real-time and historic weather data. ESS stations collect air temperature, dew point, relative humidity, wind direction, wind speed, wind gust, precipitation type and precipitation intensity. Most ESS are also equipped with a CCTV camera, which captures still images of conditions that are also shared on 511. ESS data will be used to help determine when to use the VSL system.

Road Closure Management

SDDOT closes roadways to traffic when roads are unsafe or impassible, such as during a winter storm or due to a severe crash. Road closure decisions are typically made with input from maintenance staff, department superiors, and SDHP. The SDDOT currently does not have the ability to operate these gates electronically or remotely.

WHY

39% of crashes on South Dakota Interstates and Principal Arterials occur during inclement weather conditions.



HOW

ROAD WEATHER MANAGEMENT

SCENARIO		NORMAL OPERATIONS	SEVERE WEATHER	TRAFFIC INCIDENT	SPECIAL EVENT	EQUIPMENT FAILURE
		A light snow falls, but traffic volumes are similar to clear days, and there are no incidents.	A blizzard results in portions of the freeway becoming unsafe for travel and a driver becomes stranded.	A vehicle tries to pass a snowplow and causes a crash that immobilizes the plow.	A winter storm takes place while a state high school sporting event is taking place in Sioux Falls.	An ESS stops collecting and sending data to the TOC.
EXISTING	**SDDOT ITS**	SDDOT staff update some 511/DMS alerts. SDDOT operations staff use MDSS to determine material application and track vehicles through on-vehicle sensors.	SDDOT staff monitor storm with cameras when staff is available.	SDDOT staff post messages on upstream DMS and on 511 and monitor the incident's impact via cameras.	SDDOT staff monitor MDSS, ESS, and cameras.	SDDOT staff discover the outage when trying to operate the device, and work with ITS staff and/or vendors to determine the cause of the outage and get devices functioning again.
	SDDOT DIVISION OF OPERATIONS		Field staff open and close road closure gates.	Maintenance staff track vehicle and sends out support as appropriate.	Maintenance may choose to focus operations on areas near event.	
	SD HIGHWAY PATROL	SDHP monitors the roadways for moving violations and traffic incidents, notifying SDDOT as incidents arise.	SDHP learns of stranded driver from emergency dispatch and performs rescue operations.	SDHP works with maintenance staff to clear the site of the incident and prevent secondary crashes.	N/A	N/A
WITH TOC	**TRAFFIC OPERATIONS CENTER**	TOC monitors ESS for more extreme weather conditions. Spot weather alerts are triggered by TOC for affected areas or within a radius of winter weather maintenance vehicles.	TOC monitors ESS and cameras and spots the stranded driver. TOC coordinates with emergency responders to perform rescue operations. TOC sets spot weather alerts.	TOC works with maintenance staff and SDHP to clear the crash. Spot alerts can be set to the site of the crash. TOC uses ATMS software to monitor the incident's impact on traffic via cameras and sensor data.	TOC monitors both weather and event impacts simultaneously and provide input to maintenance operations such as coordinating plow operations with event.	TOC is alerted to device failure via ATMS and given more diagnostic information on the failure. TOC works with maintenance to repair or replace equipment.

WHAT

MAINTENANCE & CONSTRUCTION INFORMATION MANAGEMENT

SDDOT is responsible for maintaining SDDOT property and facilities. This includes maintaining roadways to ensure that they remain in a state of good repair, maintaining SDDOT equipment such as ITS field devices, and routine maintenance of state right-of-way.

Roadway Maintenance & Construction

Maintenance and construction services include landscape maintenance, hazard removal, and the construction of roadways and equipment, including ITS devices. Environmental information processed by the Department's MDSS is used to aid scheduling maintenance and construction activities.

Maintenance Vehicle Tracking

Some snowplows are equipped with MDCs that capture data from plow blade sensors, air and road temperature sensors, GPS, and spreader controllers. The MDC communicates this information via cellular modem to the MDSS.

Asset Management

Asset management improves DOT planning and budgeting operations. Assets tracked and managed in a system can range from roadways and bridges to ITS devices and vehicle fleets. TOC staff can monitor information such as install or purchase dates, previous repair efforts, and expected end of life or next repair dates. Looking at assets on a larger scale helps the DOT plan for upcoming costs or downtime.

Future Opportunity: Work Zone Safety Monitoring & Management

Smart work zone technologies update SDDOT staff and the public on work zone locations and impacts. Technology usually takes the form of construction cones or barrels equipped with GPS technology which automatically update the location of the work zone. Other tools to direct traffic such as smart arrow boards and queue warning systems help manage work zones safely.

WHY

8% of the fatalities on South Dakota's Interstates and Principal Arterials occurred in work zones.

HOW

MAINTENANCE & CONSTRUCTION INFORMATION MANAGEMENT

		NORMAL OPERATIONS	SEVERE WEATHER	TRAFFIC INCIDENT	SPECIAL EVENT	EQUIPMENT FAILURE
SCENARIO		SDDOT is performing routine maintenance (such as mowing) without any expected traffic impacts.	A significant winter storm knocks down temporary traffic control devices, and requires after-hours winter maintenance work.	A crash occurs within a work zone, with one of the vehicles encroaching on the work area.	Construction on US-44 during the Sturgis Motorcycle Rally requires visitors unfamiliar to the area to use detours.	Many plow blades are reaching the expected end of life at the same time.
EXISTING	SDDOT ITS SDDOT DIVISION OF OPERATIONS	Field staff perform maintenance operations.	Winter maintenance staff perform snow and ice operations with the support of MDSS. Maintenance staff input additional observations into MDSS.	SDDOT staff are made aware of the incident after SDHP contacts them and performs traffic management operations to prevent secondary crashes.	SDDOT plans ahead of the event to minimize the impact. In addition to typical traffic controls, DMS are used to direct specific messages to rally attendees.	SDDOT staff realize the volume of equipment replacement needed during end-of-season checks.
	SD HIGHWAY PATROL	N/A	N/A	SDHP are deployed to the site for emergency response and traffic management.	SDHP allocates more resources to impacted areas	N/A
WITH TOC	TRAFFIC OPERATIONS CENTER	TOC monitors the location of maintenance work from vehicle locations and smart work zone technologies and updates 511 and DMS.	TOC monitors which roads have been cleared and treated and update 511. TOC sees via camera feeds that traffic control devices have been knocked over by strong winds and coordinates an SDDOT maintenance response.	TOC is alerted to an incident when a smart work zone device is hit. TOC notify emergency responders with the exact location of the incident.	TOC monitors traffic data across the impacted region to see if traffic control is having the intended effects. Traffic control strategies can be readjusted based on real-world impacts.	Asset management systems and plow sensors notify TOC staff that several blades are expected to wear down at the same time. Staff works out purchasing and replacement schedules to spread out large maintenance and repair efforts over time.

WHAT

SPECIAL EVENT MANAGEMENT

Special events can cause large volumes of traffic in a short period of time. Transportation systems built for much smaller typical volumes may struggle with delays and safety concerns.

Sturgis Motorcycle Rally

SDDOT and SDHP partner to form a temporary TOC during the event. SDHP gives SDDOT direct access to their CAD software. Temporary ITS equipment is deployed in the area and traffic operations such as queue detection systems that are not commonly used within the state are deployed during the event due to the increased need.

Other Special Event Management

Events other than the Sturgis Motorcycle Rally rarely have large DOT involvement. The size of these events combined with the limited resources of the DOT do not warrant the same level of response. For other events, traffic management is typically led by local agencies. Coordination between the DOT and other agencies for these events rarely exceeds normal, daily practices.

Planned Work: Queue Detection and Warning

Queue detection systems can be deployed on highways and exit ramps to identify queues and alert SDDOT staff. Exit ramp queue detection will detect vehicles backing up towards mainline lanes. These systems can be connected to the traffic signal to flush traffic on the ramp. Other traffic management strategies, such as posting messages on DMS warning drivers can also be used.

WHY

Four motorcycle crash fatalities occurred during the week-long Sturgis Motorcycle Rally in 2023

HOW

SPECIAL EVENT MANAGEMENT

		NORMAL OPERATIONS	SEVERE WEATHER	TRAFFIC INCIDENT	SPECIAL EVENT	EQUIPMENT FAILURE
SCENARIO		A concert in Sioux Falls draws thousands of people to the city.	A thunderstorm occurs during the South Dakota State Fair, prompting many attendees to leave at once.	A non-fatal crash occurs and blocks an exit ramp nearby a local event.	The Sturgis Motorcycle Rally draws nearly 500,000 visitors to Sturgis.	A portable DMS deployed for a special event is not displaying messages.
EXISTING	SDDOT ITS	SDDOT staff leave event management to local agencies.	SDDOT staff update 511 with affected areas and monitor ESS and cameras if staff are available.	SDDOT staff update 511 and DMS to direct traffic and monitor cameras if staff are available.	SDDOT partners with SDHP to create a temporary TOC and dedicates staff time and resources to perform more advanced traffic management operations.	SDDOT staff try to post a message and find that the device is not functioning. They work with field staff to fix the portable DMS in the field or swap it with another functioning sign.
	SDDOT DIVISION OF OPERATIONS					
	SD HIGHWAY PATROL	N/A	N/A	SDHP works to clear the area and prevent secondary crashes.	The SDHP gives SDDOT access to their CAD system.	N/A
WITH TOC	TRAFFIC OPERATIONS CENTER	TOC monitors traffic on state roads around the event, as well as parking availability, and post messages on DMS advising direct traffic to available parking lots. Information is shared with local agencies and law enforcement.	TOC identifies sudden changes to traffic and roadway conditions quicker and dedicate more resources to monitoring and managing traffic during events.		Effective practices from the temporary TOC have been incorporated into the TOC, such as integration of SDHP's CAD system. TOC staff will supplement the temporary TOC, providing more dedicated resources to this event.	TOC receives an alert that a device is not functioning along with more detailed diagnostic information. TOC coordinates with ITS staff to fix the portable DMS in the field or swap it with another functioning sign.

WHAT

PUBLIC SAFETY & INCIDENT MANAGEMENT

Safety is the highest priority for SDDOT. When a crash or other traffic incident occurs, response is essential for the safety of those initially involved and to protect others from secondary crashes.

Incident Response

Currently, traffic incidents are primarily addressed by SDHP. If incidents are expected to have significant impacts to traffic, SDHP may alert SDDOT staff so they may take actions such as updating DMS or SD 511. A TOC will improve the identification of incidents, decrease response times, and expedite traffic management during these times.

Emergency Call-Taking & Dispatch

State Radio and local municipalities receive 911 calls and dispatches emergency responders. CAD systems are used to manage the SDHP fleet. Past efforts to integrate SDDOT 511 systems with CAD have stalled due to technological and integration requirements.

Disaster Response & Recovery

In the case of a disaster such as extreme flooding, TOC staff can supplement public safety efforts with tools typically used for traffic operations. The TOC will coordinate with the South Dakota Office of Emergency Management to coordinate road closures, detours, notification systems, and to request additional resources. Conditions can be monitored with ESS and cameras. Traveler information systems such as DMS and mobile applications can send alerts to drivers, warning them of danger and directing them to safety in cases of evacuation.

Future Opportunity: Roadway Service Patrols

Several states operate fleets of service vehicles focused on assisting drivers, managing traffic, and clearing obstacles in the field after an incident. Staff are trained and equipped to perform operations like towing vehicles out of traffic, providing gasoline to a stalled vehicle, or directing traffic around an incident. Service fleets will typically operate in urban areas but can be deployed for events such as the Sturgis Motorcycle Rally.

Future Opportunity: Third Party Data

Another method of detecting incidents involves integrating third-party data into information systems. The SDDOT can receive data from probe vehicles to inform them of locations experiencing harsh braking or reduced speeds to help identify incidents quicker and inform drivers sooner.

WHY

South Dakota's Interstates and Principal Arterials experience **MORE THAN**

100 HOURS

a year of reduced flow due to traffic accidents

HOW

PUBLIC SAFETY & INCIDENT MANAGEMENT

		NORMAL OPERATIONS	SEVERE WEATHER	TRAFFIC INCIDENT	SPECIAL EVENT	EQUIPMENT FAILURE
SCENARIO		A typical day during rush hour with no inclement weather, traffic incidents, or lane closures.	Large volumes of rain cause flooding in several areas with the potential to escalate to evacuations.	A car crash involving several vehicles and causing life-threating injuries occurs.	A major event pushes long traffic queues onto Interstate mainline.	A camera pole is struck by a vehicle and part of the damaged equipment is laying on the roadway.
EXISTING	**SDDOT ITS** **SDDOT DEPARTMENT OF OPERATIONS**	SDDOT staff remain ready to react to roadway incidents when they are notified of an event.	SDDOT staff monitor conditions with ESS and cameras if staff are available. Safety and traffic information are updated on DMS and 511.	SDDOT staff monitor area with cameras when staff is available, and post messages to DMS and 511 as needed.		SDDOT staff learn of the issue when the crash is reported to SDHP. Field staff work to first remove the debris from the roadway and eventually replace the device.
	SD HIGHWAY PATROL	SDHP monitors the roadways for moving violations and traffic incidents, notifying SDDOT as incidents arise.	SDHP guides traffic in the field and assists with evacuations if necessary.	SDHP assists those involved at the scene and works to clear the incident. SDHP informs SDDOT so they can manage traffic operations in the area.	SDHP assist with directing traffic to dissipate queues.	SDHP heads to the site to document the incident and direct traffic.
WITH TOC	**TRAFFIC OPERATIONS CENTER**	TOC monitors traffic for unplanned events or incidents and deploys traffic management strategies as appropriate.	TOC monitors conditions with ESS and cameras. Safety information, traffic direction, and (if necessary) evacuation guidance is posted to DMS and 511. TOC staff works with Emergency Management and SDHP dispatch to deploy areas of highest need.	TOC monitors the area and deploy appropriate traffic management techniques such as using VSL to reduce vehicle speeds. Roadway service patrols are deployed to the site to guide traffic and clear debris so SDHP and paramedics can focus on emergency response.	TOC monitors traffic and deploy traffic management strategies as needed. Roadway service patrols coordinate with emergency dispatch to be ready in case of incident.	TOC is notified of a device issue by ATMS. TOC dispatches roadway service patrols to help direct traffic and clear debris.

WHAT

COMMERCIAL VEHICLE OPERATIONS

Commercial vehicles play an important role in the economy of both South Dakota and the United States as whole. The SDDOT and SDHP work in tandem to ensure the safety of those on the road and the long-term health of the State transportation network.

Port of Entry & Weigh-In-Motion Systems

There are several screening and weigh stations for commercial vehicles throughout the state managed by SDHP. Traditional weigh stations have infrastructure for SDHP to inspect vehicles for compliance with commercial vehicle restrictions and policies. Other devices to sense safety or restriction violations, such as infrared braking heat sensors or over-height vehicle detectors, may also be at screening and weigh stations.

Truck Oversize/Overweight Travel Planning

Restrictions on commercial vehicles are made available for drivers in several locations. 511 includes a layer displaying the weight limits for roadways. Temporary restrictions are also flagged on the map. Restrictions and other commercial vehicle information is also made available on the South Dakota Truck Info website.

Future Opportunity: Truck Parking Availability Information

Commercial vehicle drivers often face challenges locating a suitable location to park their vehicles for legally required breaks. Searching for available spaces can take upwards of an hour and results in drivers taking inefficient routes or wasting fuel. Many states have implemented truck parking systems that track the number of available truck parking spaces at rest areas or private parking lots. That number is then conveyed to drivers via DMS and 511.

WHY

South Dakota's Interstates consist of 23% commercial vehicle traffic.

HOW

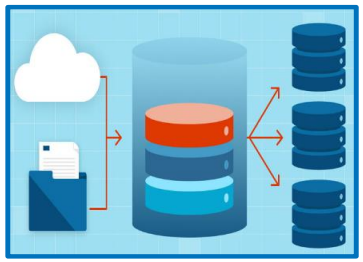
COMMERCIAL VEHICLE OPERATIONS

SCENARIO		NORMAL OPERATIONS	SEVERE WEATHER	TRAFFIC INCIDENT	SPECIAL EVENT	EQUIPMENT FAILURE
		A typical day during rush hour with no inclement weather, traffic incidents, or lane closures.	A winter storm closes the freeway due to ice.	A commercial vehicle rolls over and spills its cargo onto the roadway.	Spring leads to temporary weight restrictions in the area.	An overheight detector at a weigh-in-motion site begins malfunctioning.
EXISTING	SDDOT ITS	N/A	SDDOT staff post messages to DMS and 511 alerting vehicles of the closure and informing them which exit to take. Staff manually lower road closure gates.	SDDOT staff learn of incident from SDHP and perform appropriate traffic management operations. Field staff are deployed to clear debris from roadway.	SDDOT and SDHP staff update restrictions on 511 and South Dakota Truck Info site and phone line.	SDDOT and SDHP are not aware of the issue until SDHP visits the site to monitor vehicles. SDHP notifies SDOT and ITS staff work with the vendor to repair or replace equipment.
	SDDOT DIVISION OF OPERATIONS					
	SD HIGHWAY PATROL	SDHP stationed at screening and weigh stations conduct routine inspections.	N/A	SDHP responds to scene and help control traffic until scene is cleared.	SDHP at weigh stations convey information to drivers about nearby temporary restrictions.	N/A
WITH TOC	TRAFFIC OPERATIONS CENTER	TOC monitors the health and performance of sensors and truck parking availability systems.	TOC posts closure information to DMS and 511 and remotely close roads. DMS provide truck parking availability so drivers can safely wait out the storm.	TOC monitors area and work with SDHP to perform appropriate traffic management operations. TOC coordinates with hazardous material specialists for toxic cleanup as necessary.	TOC updates restrictions on 511 and South Dakota Truck Info site and phone line. TOC may work with field staff to deploy portable DMS to deliver weight restriction messages.	TOC is alerted by ATMS of the device error shortly after equipment begins malfunctioning and work with ITS staff to repair or replace equipment.

WHAT
DATA MANAGEMENT

Data Storage & Analysis

ESS, vehicle detectors, cameras, and many other ITS devices collect and store data. However, with the exception of MDSS, this data is rarely used in any kind of analysis nor is there a central repository for data to be stored. The ATMS will act as a one-stop shop to view data from all of these devices. With the addition of more ITS devices and as the world becomes more data-driven, it is expected that the data needs and goals of SDDOT will only grow.



Future Opportunity: Performance Monitoring

SDDOT wishes to implement metrics and analyze data to evaluate the entire transportation system. This will require data analysis software or tools to determine patterns and present findings in a suitable format.

Future Opportunity: Predictive Analytics

Data fusion, analytics, and AI tools help to identify the location, nature, and severity of previously difficult-to-identify safety concerns. With big data sets from sources such as connected vehicles, data such as vehicle acceleration and harsh braking can be analyzed to determine locations with high crash rates.

Future Opportunity: ITS Data Warehouse

As part of the long-term TOC vision, SDDOT would like to establish an ITS data warehouse that would archive data pulled from ITS devices and systems. Once implemented, the data warehouse can be expanded as more ITS is deployed around the state. SDDOT may choose to collaborate with partners such as universities to share data and findings.

WHY

CURRENTLY 511 SEES OVER

900 ENTRIES PER YEAR

a number that will increase exponentially as new technology systems are deployed

HOW

DATA MANAGMENT

SCENARIO		NORMAL OPERATIONS	SEVERE WEATHER	TRAFFIC INCIDENT	SPECIAL EVENT	EQUIPMENT FAILURE
		 Data Type: Traffic volumes, congestion patterns, and carbon emissions.	 Data Type: Roadway clearance times, material usage, and historical weather patterns.	 Data Type: Crash count, type, location, and severity.	 Data Type: Sturgis Motorcycle Rally metrics	 Data Type: Device Downtime
EXISTING	**SDDOT ITS**	Only basic data such as traffic volumes are collected by SDDOT.	MDSS data is collected and stored to help plan for future maintenance operations.	Significant crash data is collected and analyzed.	N/A	N/A
	SDDOT DIVISION OF OPERATIONS					
	SD HIGHWAY PATROL	N/A	N/A		N/A	N/A
WITH TOC	**TRAFFIC OPERATIONS CENTER**	Evaluate effectiveness of traffic management strategies. Detailed ADT and truck volumes help the SDDOT to plan for future projects, informing needs and helping to effectively prioritize projects.	Incorporate MDSS data with other data types.	Data detailing incident locations, delay, and clearance times can be used to identify areas of need, such as gaps in camera or detector coverage, or areas where drivers could use better information dissemination.	Data detailing speed, crashes, and congestion can help the SDDOT identify problem areas to focus monitoring, deploy additional traffic control, and identify routing information that can be posted to DMS and 511.	Tracking device downtime will inform many decisions, such as asset management, maintenance scheduling, and budget justifications. The TOC also can track response and repair times.

Appendix B: Traffic Operations Center Functions – Text & Table Format

What: Traffic Management

SDDOT is responsible for managing the statewide transportation network including collecting, processing, and disseminating a wide range of information and data. The ability to quickly detect and verify events impacting the transportation network combined with the ability to inform others helps SDDOT effectively manage operations and implement actions to reduce impacts when events occur.

Existing Practice - Traffic Monitoring: SDDOT currently owns and operates cameras and vehicle detectors throughout the state but does not have dedicated staff available to monitor traffic. During certain times such as a winter storm or a significant crash, the DOT may choose to dedicate staff to monitoring devices to help identify and respond to incidents faster.

Planned Work – Advanced Traffic Management System: SDDOT plans to procure an advanced traffic management system (ATMS) in 2025. ATMS will give the SDDOT the ability to control many ITS devices from a remote location, allowing staff to centralize existing traffic operations and perform more complex traffic management operations within the same software.

Planned Work – Variable Speed Limits: SDDOT is currently planning to deploy variable speed limit (VSL) systems along multiple Interstate corridors. These systems will temporarily lower speed limits during certain periods to improve safety. VSL systems require careful monitoring, to ensure that speed limit adjustments are timely in response to changes to roadway conditions.

Future Opportunities – Wrong-Way Vehicle Detection: At locations with a history of wrong-way incidents, a detection and deterrence system can be implemented to help prevent crashes. Sensors on ramps detect vehicles traveling in the wrong direction and can trigger DMS or simply notify TOC staff. After verifying an incident via CCTV cameras, TOC staff can alert first responders and post messages on DMS warning traffic.

Why Traffic Management?

23% of congestion on South Dakota Interstates and Principal Arterials occur during recurring congestion events in Sioux Falls, Rapid City, Aberdeen, and Brookings, construction work zones or special events.

Table 12: How: Traffic Management Practices

	Normal Operations	*Severe Weather*	*Traffic Incident*	*Special Event*	*Equipment Failure*
Scenario	A typical day during rush hour with no inclement weather, traffic incidents, or lane closures.	A winter storm with significant snowfall leads to road closures.	A wrong-way driver enters the freeway.	A SDSU football game draws high traffic volumes near campus.	A communications network failure impacts dozens of devices in the area.
Existing Practices: SDDOT ITS and SDDOT Division of Operations	SDDOT remain ready to react to roadway incidents when they are notified of an event.	SDDOT staff monitor storm with CCTV cameras when staff is available. Field staff open and close road closure gates.	SDDOT staff likely have no idea that a wrong-way event has occurred until it is over.	SDDOT staff monitor area with CCTV cameras when staff is available, and post messages to DMS and 511 as needed	SDDOT staff discover the outage when trying to operate the device, and work with field staff and/or BIT to determine the cause of the outage and get devices functioning again.
Existing Practices: SD Highway Patrol	SDHP monitors the roadways for moving violations and traffic incidents, notifying SDDOT as incidents arise.	SDHP responds to incidents as they occur.	SDHP deploy officers to stop driver and protect others on the roadway.	SDHP monitors traffic near event and directs traffic when signals become overwhelmed.	N/A
Future Practices: With a Traffic Operations Center	TOC monitors traffic for unplanned events or incidents and deploy traffic management strategies as needed	TOC monitors conditions on CCTV cameras. TOC staff remotely control road closure gates. Staff use VSL to lower speed limits and monitor to return speed limits to normal later.	Detection systems alert TOC of a wrong-way driver. TOC staff monitor situation via CCTV cameras. TOC posts messages to DMS to warn drivers of a wrong-way vehicle in the area.	TOC monitors conditions on CCTV cameras. TOC monitor queue detection for traffic backing up on ramps and advise event traffic to use specific routes to the stadium.	TOC is notified of outages and given diagnostic information via ATMS. TOC staff work with contractors or maintenance staff to bring communications back online.

What: Traveler Information

SDDOT is responsible for disseminating a wide range of information to the traveling public and operational partners. Effective traveler information systems, based on real-time data, help SDDOT effectively manage operations and implement actions to mitigate adverse impacts when events occur.

Existing Practice – South Dakota 511: SDDOT operates a traveler information system to inform travelers of real-time travel conditions. Information on weather and road conditions, commercial vehicle restrictions, events, and incidents are available to the public via mobile phone application, website, kiosks at rest areas, or by calling 511. Users can also sign up for text or email alerts for specific information.

Existing Practice – Dynamic Message Signs: SDDOT owns and operates fixed DMS as well as many portable DMS used to supplement fixed signs during temporary traffic events such as construction.

Future Opportunity - Location-Based Alerts: Both the public and private sectors have explored ways to communicate information to drivers based on GPS location using smartphones and in-vehicle displays. Alerts convey similar information that would be available in 511 or on DMS, but the alerts are only triggered when the driver is within a certain distance from the area of concern.

Future Opportunity – Crowdsourced Information: Both the public and private sectors have explored ways to communicate information to drivers based on GPS location using smartphones and in-vehicle displays. Alerts convey similar information that would be available in 511 or on DMS, but the alerts are only triggered when the driver is within a certain distance from the area of concern.

Why Traveler Information?

77% of congestion on South Dakota Interstates and Principal Arterials occur during unplanned events related to weather, crashes, and roadway maintenance that would benefit from enhanced and expanded traveler information.

Table 13: How: Traveler Information Practices

	Normal Operations	*Severe Weather*	*Traffic Incident*	*Special Event*	*Equipment Failure*
Scenario	A typical day during rush hour with no inclement weather, traffic incidents, or lane closures.	A winter storm with limited visibility and slick roadway surfaces.	A car crash involving several vehicles closes a lane of traffic.	LifeLight, a music festival draws 25 thousand people to Sioux Falls.	A DMS stops functioning and cannot display messages.
Existing Practices: SDDOT ITS and SDDOT Division of Operations	SDDOT remain ready to react to roadway incidents when they are notified of an event.	SDDOT staff update DMS with severe weather warnings and advisories. ESS data is processed by the MDSS and pushed to 511.	SDDOT staff update DMS upstream with lane closure and crash information. If the incident is expected to take several hours to clear, it may be added to SD 511.	SDDOT staff update DMS to direct traffic. Events can be added to SD 511.	SDDOT staff may not notice the failure until they attempt to use the sign. Staff can use SD 511 and nearby DMS to convey messages. Operations staff will work with field staff to deploy portable DMS if needed.
Existing Practices: SD Highway Patrol	SDHP monitors the roadways for moving violations and traffic incidents, notifying SDDOT as incidents arise.	SDHP coordinates with SDDOT to update winter storm messages in 511 and on DMS.	SDHP coordinates with SDDOT to update incident messages in 511 and on DMS.	SDHP coordinates with SDDOT to update event messages in 511 and on DMS.	N/A
Future Practices: With a Traffic Operations Center	TOC monitors traffic conditions via cameras, field sensors, and conversations with field staff and posts messages to DMS and 511 as congestion occurs.	TOC monitors weather via ESS, cameras, and conversations with field staff, inputting additional weather information into 511 and updating DMS messages as conditions change. Location-based alerts are sent to those in the storm and near winter operations vehicles.	TOC verifies and monitor incidents with cameras and field sensor data. TOC coordinates an appropriate response based on severity of the incident with emergency dispatch, tow trucks, and maintenance. TOC inputs incidents into 511 and updates DMS and location-specific alerts.	TOC schedules special event messages, such as suggested event traffic routing, to be posted via DMS, 511, and location-specific alerts. During the event, TOC monitors traffic in the area and updates messages as needed. TOC may coordinate with police if special traffic direction is needed.	TOC receives an alert about the equipment failure and coordinate maintenance with SDDOT ITS, resulting in reduced downtime.

What: Road Weather Management

Weather plays a large impact on the safety and reliability of transportation. Many resources are devoted to keeping roadway surfaces clear and safe for travel. Traffic operations must combat the risks posed by limited visibility and slick roadways.

Existing Practice – Winter Maintenance: To address winter weather effectively and efficiently, SDDOT uses a variety of technologies to gather data, inform travelers, and manage equipment. Normal winter maintenance operations occur during a storm but may be extended if highway/traffic conditions warrant and if staff is available.

Existing Practice – Environmental Sensor Stations: The DOT maintains ESS, which compile real-time and historic weather data. ESS stations collect air temperature, dew point, relative humidity, wind direction, wind speed, wind gust, precipitation type and precipitation intensity. Most ESS are also equipped with a CCTV camera, which captures still images of conditions that are also shared on 511. ESS data will be used to help determine when to use the VSL system.

Existing Practice – Maintenance Decision and Support Systems: MDSS pulls and analyzes weather and road condition data from ESS, in-vehicle plow equipment, and feedback from operations staff. MDSS provides recommendations on material to use, the application rate, and when application should occur. The system also tracks maintenance activities throughout a winter storm.

Existing Practice – Road Closure Management: SDDOT closes roadways to traffic when roads are unsafe or impassible, such as during a winter storm or due to a severe crash. Road closure decisions are typically made with input from maintenance staff, department superiors, and SDHP. The SDDOT currently does not have the ability to operate these gates electronically or remotely.

Future Opportunity – Spot Weather Warnings: Using devices on winter maintenance vehicles, alerts can be sent to motorists when they are within a certain proximity of the vehicle. Drivers would be notified through their phone or on the dashboard of a connected vehicle. The warning would advise drivers to use caution when near the maintenance vehicle and could also include important weather information pulled from SDDOT's MDSS or RWIS.

Why Road Weather Management?

39% of crashes on South Dakota Interstates and Principal Arterials occur during inclement weather conditions.

Table 14: How: Road Weather Management Practices

	Normal Operations	*Severe Weather*	*Traffic Incident*	*Special Event*	*Equipment Failure*
Scenario	A light snow falls, but traffic volumes are similar to clear days, and there are no incidents.	A blizzard results in portions of the freeway becoming unsafe for travel and a driver becomes stranded.	A vehicle tries to pass a snowplow and causes a crash that immobilizes the plow.	A winter storm takes place while a state high school sporting event is taking place in Sioux Falls.	An ESS stops collecting and sending data to the TOC.
Existing Practices: SDDOT ITS and SDDOT Division of Operations	SDDOT staff update some 511/DMS alerts. SDDOT operations staff use MDSS to determine material application and track vehicles through on-vehicle sensors.	SDDOT staff monitor storm with cameras when staff is available. Field staff open and close road closure gates.	SDDOT staff post messages on upstream DMS and on 511 and monitor the incident's impact via cameras. Maintenance staff track vehicle and sends out support as appropriate.	SDDOT staff monitor MDSS, ESS, and cameras. Maintenance may choose to focus operations on areas near event.	SDDOT staff discover the outage when trying to operate the device, and work with ITS staff and/or vendors to determine the cause of the outage and get devices functioning again.
Existing Practices: SD Highway Patrol	SDHP monitors the roadways for moving violations and traffic incidents, notifying SDDOT as incidents arise.	SDHP learns of stranded driver from emergency dispatch and performs rescue operations.	SDHP works with maintenance staff to clear the site of the incident and prevent secondary crashes.	N/A	N/A
Future Practices: With a Traffic Operations Center	TOC monitors ESS for more extreme weather conditions. Spot weather alerts are triggered by TOC for affected areas or within a radius of winter weather maintenance vehicles.	TOC monitors ESS and cameras and spots the stranded driver. TOC coordinates with emergency responders to perform rescue operations. TOC sets spot weather alerts.	TOC works with maintenance staff and SDHP to clear the crash. Spot alerts can be set to the site of the crash. TOC uses ATMS software to monitor the incident's impact on traffic via cameras and sensor data.	TOC monitors both weather and event impacts simultaneously and provide input to maintenance operations such as coordinating plow operations with event.	TOC is alerted to device failure via ATMS and given more diagnostic information on the failure. TOC works with maintenance to repair or replace equipment.

What: Maintenance and Construction Information Management

SDDOT is responsible for maintaining SDDOT property and facilities. This includes maintaining roadways to ensure that they remain in a state of good repair, maintaining SDDOT equipment such as ITS field devices, and routine maintenance of state right-of-way.

Existing Practice – Roadway Maintenance & Construction: Maintenance and construction services include landscape maintenance, hazard removal, and the construction of roadways and equipment, including ITS devices. Environmental information processed by the Department's MDSS is used to aid scheduling maintenance and construction activities.

Existing Practice – Maintenance Vehicle Tracking: Some snowplows are equipped with MDCs that capture data from plow blade sensors, air and road temperature sensors, GPS, and spreader controllers. The MDC communicates this information via cellular modem to the MDSS.

Existing Practice – Asset Management: Asset management improves DOT planning and budgeting operations. Assets tracked and managed in a system can range from roadways and bridges to ITS devices and vehicle fleets. TOC staff can monitor information such as install or purchase dates, previous repair efforts, and expected end of life or next repair dates. Looking at assets on a larger scale helps the DOT plan for upcoming costs or downtime.

Future Opportunity – Work Zone Safety Monitoring & Management: Smart work zone technologies update SDDOT staff and the public on work zone locations and impacts. Technology usually takes the form of construction cones or barrels equipped with GPS technology which automatically update the location of the work zone. Other tools to direct traffic such as smart arrow boards and queue warning systems help manage work zones safely.

Why Maintenance and Construction Information Management?

8% of the fatalities on South Dakota's Interstates and Principal Arterials occurred in work zones.

Table 15: How: Maintenance and Construction Information Management Practices

	Normal Operations	*Severe Weather*	*Traffic Incident*	*Special Event*	*Equipment Failure*
Scenario	SDDOT is performing routine maintenance (such as mowing) without any expected traffic impacts.	A significant winter storm knocks down temporary traffic control devices, and requires after-hours winter maintenance work.	A crash occurs within a work zone, with one of the vehicles encroaching on the work area.	Construction on US-44 during the Sturgis Motorcycle Rally requires visitors unfamiliar to the area to use detours.	Many plow blades are reaching the expected end of life at the same time.
Existing Practices: SDDOT ITS and SDDOT Division of Operations	Field staff perform maintenance operations.	Winter maintenance staff perform snow and ice operations with the support of MDSS. Maintenance staff input additional observations into MDSS.	SDDOT staff are made aware of the incident after SDHP contacts them and performs traffic management operations to prevent secondary crashes.	SDDOT plans ahead of the event to minimize the impact. In addition to typical traffic controls, DMS are used to direct specific messages to rally attendees.	SDDOT staff realize the volume of equipment replacement needed during end-of-season checks.
Existing Practices: SD Highway Patrol	N/A	N/A	SDHP are deployed to the site for emergency response and traffic management.	SDHP allocates more resources to impacted areas.	N/A
Future Practices: With a Traffic Operations Center	TOC monitors the location of maintenance work from vehicle locations and smart work zone technologies and updates 511 and DMS.	TOC monitors which roads have been cleared and treated and update 511. TOC sees via camera feeds that traffic control devices have been knocked over by strong winds and coordinates an SDDOT maintenance response.	TOC is alerted to an incident when a smart work zone device is hit. TOC notify emergency responders with the exact location of the incident.	TOC monitors traffic data across the impacted region to see if traffic control is having the intended effects. Traffic control strategies can be readjusted based on real-world impacts.	Asset management systems and plow sensors notify TOC staff that several blades are expected to wear down at the same time. Staff works out purchasing and replacement schedules to spread out large maintenance and repair efforts over time.

What: Special Event Management

Special events can cause large volumes of traffic in a short period of time. Transportation systems built for much smaller typical volumes may struggle with delays and safety concerns.

Existing Practice – Sturgis Motorcycle Rally: SDDOT and SDHP partner to form a temporary TOC during the event. SDHP gives SDDOT direct access to their CAD software. Temporary ITS equipment is deployed in the area and traffic operations such as queue detection systems that are not commonly used within the state are deployed during the event due to the increased need.

Existing Practice – Other Special Event Management: Events other than the Sturgis Motorcycle Rally rarely have large DOT involvement. The size of these events combined with the limited resources of the DOT do not warrant the same level of response. For other events, traffic management is typically led by local agencies. Coordination between the DOT and other agencies for these events rarely exceeds normal, daily practices.

Planned Work – Queue Detection and Warning: Queue detection systems can be deployed on highways and exit ramps to identify queues and alert SDDOT staff. Exit ramp queue detection will detect vehicles backing up towards mainline lanes. These systems can be connected to the traffic signal to flush traffic on the ramp. Other traffic management strategies, such as posting messages on DMS warning drivers can also be used.

Why Special Event Management?

Four motorcycle crash fatalities occurred during the week-long Sturgis Motorcycle Rally in 2023.

Table 16: How: Special Event Management Practices

	Normal Operations	*Severe Weather*	*Traffic Incident*	*Special Event*	*Equipment Failure*
Scenario	A concert in Sioux Falls draws thousands of people to the city.	A thunderstorm occurs during the South Dakota State Fair, prompting many attendees to leave at once.	A non-fatal crash occurs and blocks an exit ramp nearby a local event.	The Sturgis Motorcycle Rally draws nearly 500,000 visitors to Sturgis.	A portable DMS deployed for a special event is not displaying messages.
Existing Practices: SDDOT ITS and SDDOT Division of Operations	SDDOT staff leave event management to local agencies.	SDDOT staff update 511 with affected areas and monitor ESS and cameras if staff are available.	SDDOT staff update 511 and DMS to direct traffic and monitor cameras if staff are available.	SDDOT partners with SDHP to create a temporary TOC and dedicates staff time and resources to perform more advanced traffic management operations.	SDDOT staff try to post a message and find that the device is not functioning. They work with field staff to fix the portable DMS in the field or swap it with another functioning sign.
Existing Practices: SD Highway Patrol	N/A	N/A	SDHP works to clear the area and prevent secondary crashes.	The SDHP gives SDDOT access to their CAD system.	N/A
Future Practices: With a Traffic Operations Center	TOC monitors traffic on state roads around the event, as well as parking availability, and post messages on DMS advising direct traffic to available parking lots. Information is shared with local agencies and law enforcement.	TOC identifies sudden changes to traffic and roadway conditions quicker and dedicate more resources to monitoring and managing traffic during events.	TOC identifies sudden changes to traffic and roadway conditions quicker and dedicate more resources to monitoring and managing traffic during events.	Effective practices from the temporary TOC have been incorporated into the TOC, such as integration of SDHP's CAD system. TOC staff will supplement the temporary TOC, providing more dedicated resources to this event.	TOC receives an alert that a device is not functioning along with more detailed diagnostic information. TOC coordinates with ITS staff to fix the portable DMS in the field or swap it with another functioning sign.

What: Public Safety and Incident Management

Safety is the highest priority for SDDOT. When a crash or other traffic incident occurs, response is essential for the safety of those initially involved and to protect others from secondary crashes.

Existing Practice – Incident Response: Currently, traffic incidents are primarily addressed by SDHP. If incidents are expected to have significant impacts to traffic, SDHP may alert SDDOT staff so they may take actions such as updating DMS or SD 511. A TOC will improve the identification of incidents, decrease response times, and expedite traffic management during these times.

Existing Practice – Emergency Call-Taking and Dispatch: State Radio and local municipalities receive 911 calls and dispatches emergency responders. CAD systems are used to manage the SDHP fleet. Past efforts to integrate SDDOT 511 systems with CAD have stalled due to technological and integration requirements.

Existing Practice – Disaster Response & Recovery: In the case of a disaster such as extreme flooding, TOC staff can supplement public safety efforts with tools typically used for traffic operations. The TOC will coordinate with the South Dakota Office of Emergency Management to coordinate road closures, detours, notification systems, and to request additional resources. Conditions can be monitored with ESS and cameras. Traveler information systems such as DMS and mobile applications can send alerts to drivers, warning them of danger and directing them to safety in cases of evacuation.

Future Opportunity – Roadway Service Patrols: Several states operate fleets of service vehicles focused on assisting drivers, managing traffic, and clearing obstacles in the field after an incident. Staff are trained and equipped to perform operations like towing vehicles out of traffic, providing gasoline to a stalled vehicle, or directing traffic around an incident. Service fleets will typically operate in urban areas but can be deployed for events such as the Sturgis Motorcycle Rally.

Future Opportunity – Third Party Data: Another method of detecting incidents involves integrating third-party data into information systems. The SDDOT can receive data from probe vehicles to inform them of locations experiencing harsh braking or reduced speeds to help identify incidents quicker and inform drivers sooner.

Why Public Safety and Incident Management?

South Dakota's interstates and principal arterials experience more than 100 hours a year of reduced flow due to traffic accidents.

Table 17: How: Public Safety & Incident Management Practices

	Normal Operations	*Severe Weather*	*Traffic Incident*	*Special Event*	*Equipment Failure*
Scenario	A typical day during rush hour with no inclement weather, traffic incidents, or lane closures.	Large volumes of rain cause flooding in several areas with the potential to escalate to evacuations.	A car crash involving several vehicles and causing life-threating injuries occurs.	A major event pushes long traffic queues onto Interstate mainline.	A camera pole is struck by a vehicle and part of the damaged equipment is laying on the roadway.
Existing Practices: SDDOT ITS and SDDOT Division of Operations	SDDOT staff remain ready to react to roadway incidents when they are notified of an event.	SDDOT staff monitor conditions with ESS and cameras if staff are available. Safety and traffic information are updated on DMS and 511.	SDDOT staff monitor area with cameras when staff is available, and post messages to DMS and 511 as needed.	SDDOT staff monitor area with cameras when staff is available, and post messages to DMS and 511 as needed.	SDDOT staff learn of the issue when the crash is reported to SDHP. Field staff work to first remove the debris from the roadway and eventually replace the device.
Existing Practices: SD Highway Patrol	SDHP monitors the roadways for moving violations and traffic incidents, notifying SDDOT as incidents arise.	SDHP guides traffic in the field and assists with evacuations if necessary.	SDHP assists those involved at the scene and works to clear the incident. SDHP informs SDDOT so they can manage traffic operations in the area.	SDHP assist with directing traffic to dissipate queues.	SDHP heads to the site to document the incident and direct traffic.
Future Practices: With a Traffic Operations Center	TOC monitors traffic for unplanned events or incidents and deploys traffic management strategies as appropriate.	TOC monitors conditions with ESS and cameras. Safety information, traffic direction, and (if necessary) evacuation guidance is posted to DMS and 511. TOC staff works with Emergency Management and SDHP dispatch to deploy areas of highest need.	TOC monitors the area and deploy appropriate traffic management techniques such as using VSL to reduce vehicle speeds. Roadway service patrols are deployed to the site to guide traffic and clear debris so SDHP and paramedics can focus on emergency response.	TOC monitors traffic and deploy traffic management strategies as needed. Roadway service patrols coordinate with emergency dispatch to be ready in case of incident.	TOC is notified of a device issue by ATMS. TOC dispatches roadway service patrols to help direct traffic and clear debris.

What: Commercial Vehicle Operations

Commercial vehicles play an important role in the economy of both South Dakota and the United States as whole. The SDDOT and SDHP work in tandem to ensure the safety of those on the road and the long-term health of the State transportation network.

Existing Practice – Port of Entry & Weigh-in-Motion Systems: There are several screening and weigh stations for commercial vehicles throughout the state managed by SDHP. Traditional weigh stations have infrastructure for SDHP to inspect vehicles for compliance with commercial vehicle restrictions and policies. Other devices to sense safety or restriction violations, such as infrared braking heat sensors or over-height vehicle detectors, may also be at screening and weigh stations.

Existing Practice – Truck Oversize/Overweight Travel Planning: Restrictions on commercial vehicles are made available for drivers in several locations. 511 includes a layer displaying the weight limits for roadways. Temporary restrictions are also flagged on the map. Restrictions and other commercial vehicle information is also made available on the South Dakota Truck Info website.

Future Opportunity – Truck Parking Availability Information: Commercial vehicle drivers often face challenges locating a suitable location to park their vehicles for legally required breaks. Searching for available spaces can take upwards of an hour and results in drivers taking inefficient routes or wasting fuel. Many states have implemented truck parking systems that track the number of available truck parking spaces at rest areas or private parking lots. That number is then conveyed to drivers via DMS and 511.

Why Commercial Vehicle Operations?

South Dakota's interstates consist of 23% commercial vehicle traffic.

Table 18: How: Commercial Vehicle Operations Practices

	Normal Operations	*Severe Weather*	*Traffic Incident*	*Special Event*	*Equipment Failure*
Scenario	A typical day during rush hour with no inclement weather, traffic incidents, or lane closures.	A winter storm closes the freeway due to ice.	A commercial vehicle rolls over and spills its cargo onto the roadway.	Spring leads to temporary weight restrictions in the area.	An overheight detector at a weigh-in-motion site begins malfunctioning.
Existing Practices: SDDOT ITS and SDDOT Division of Operations	N/A	SDDOT staff post messages to DMS and 511 alerting vehicles of the closure and informing them which exit to take. Staff manually lower road closure gates.	SDDOT staff learn of incident from SDHP and perform appropriate traffic management operations. Field staff are deployed to clear debris from roadway.	SDDOT and SDHP staff update restrictions on 511 and South Dakota Truck Info site and phone line.	SDDOT and SDHP are not aware of the issue until SDHP visits the site to monitor vehicles. SDHP notifies SDOT and ITS staff work with the vendor to repair or replace equipment.
Existing Practices: SD Highway Patrol	SDHP stationed at screening and weigh stations conduct routine inspections.	N/A	SDHP responds to scene and help control traffic until scene is cleared.	SDHP at weigh stations convey information to drivers about nearby temporary restrictions.	N/A
Future Practices: With a Traffic Operations Center	TOC monitors the health and performance of sensors and truck parking availability systems.	TOC posts closure information to DMS and 511 and remotely close roads. DMS provide truck parking availability so drivers can safely wait out the storm.	TOC monitors area and work with SDHP to perform appropriate traffic management operations. TOC coordinates with hazardous material specialists for toxic cleanup as necessary.	TOC updates restrictions on 511 and South Dakota Truck Info site and phone line. TOC may work with field staff to deploy portable DMS to deliver weight restriction messages.	TOC is alerted by ATMS of the device error shortly after equipment begins malfunctioning and work with ITS staff to repair or replace equipment.

What: Data Management

Traffic operations and technology grant DOTs the opportunities to analyze patterns and make decisions based on large sums of data. Big data has become more integral across many industries, but organizing and analyzing the data into anything useful requires a strong data structure and data practices.

Existing Practice – Data Storage & Analysis: ESS, vehicle detectors, cameras, and many other ITS devices collect and store data. However, with the exception of MDSS, this data is rarely used in any kind of analysis nor is there a central repository for data to be stored. The ATMS will act as a one-stop shop to view data from all of these devices. With the addition of more ITS devices and as the world becomes more data-driven, it is expected that the data needs and goals of SDDOT will only grow.

Future Opportunity – ITS Data Warehouse: As part of the long-term TOC vision, SDDOT would like to establish an ITS data warehouse that would archive data pulled from ITS devices and systems. Once implemented, the data warehouse can be expanded as more ITS is deployed around the state. SDDOT may choose to collaborate with partners such as universities to share data and findings.

Future Opportunity – Performance Monitoring: SDDOT wishes to implement metrics and analyze data to evaluate the entire transportation system. This will require data analysis software or tools to determine patterns and present findings in a suitable format.

Future Opportunity – Predictive Analytics: Data fusion, analytics, and AI tools help to identify the location, nature, and severity of previously difficult-to-identify safety concerns. With big data sets from sources such as connected vehicles, data such as vehicle acceleration and harsh braking can be analyzed to determine locations with high crash rates.

Why Data Management?

Currently, SD 511 sees over 900 entries per year, a number that will increase exponentially as new technology systems are deployed.

Table 19: How: Data Management Practices

	Normal Operations	*Severe Weather*	*Traffic Incident*	*Special Event*	*Equipment Failure*
Scenario	Data Type: Traffic volumes, congestion patterns, and carbon emissions.	Data Type: Roadway clearance times, material usage, and historical weather patterns.	Data Type: Crash count, type, location, and severity.	Data Type: Sturgis Motorcycle Rally metrics	Data Type: Device Downtime
Existing Practices: SDDOT ITS and SDDOT Division of Operations	Only basic data such as traffic volumes are collected by SDDOT.	MDSS data is collected and stored to help plan for future maintenance operations.	Significant crash data is collected and analyzed.	N/A	N/A
Existing Practices: SD Highway Patrol	N/A	N/A	Significant crash data is collected and analyzed.	N/A	N/A
Future Practices: With a Traffic Operations Center	Evaluate effectiveness of traffic management strategies. Detailed ADT and truck volumes help the SDDOT to plan for future projects, informing needs and helping to effectively prioritize projects.	Incorporate MDSS data with other data types.	Data detailing incident locations, delay, and clearance times can be used to identify areas of need, such as gaps in camera or detector coverage, or areas where drivers could use better information dissemination.	Data detailing speed, crashes, and congestion can help the SDDOT identify problem areas to focus monitoring, deploy additional traffic control, and identify routing information that can be posted to DMS and 511.	Tracking device downtime will inform many decisions, such as asset management, maintenance scheduling, and budget justifications. The TOC also can track response and repair times.